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San Juan Bay and Estuary Study: Hydrodynamic Field Data Collection

by Timothy L. Fagerburg

Prepared for U.S. Army Engineer District, Jacksonville

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Final report

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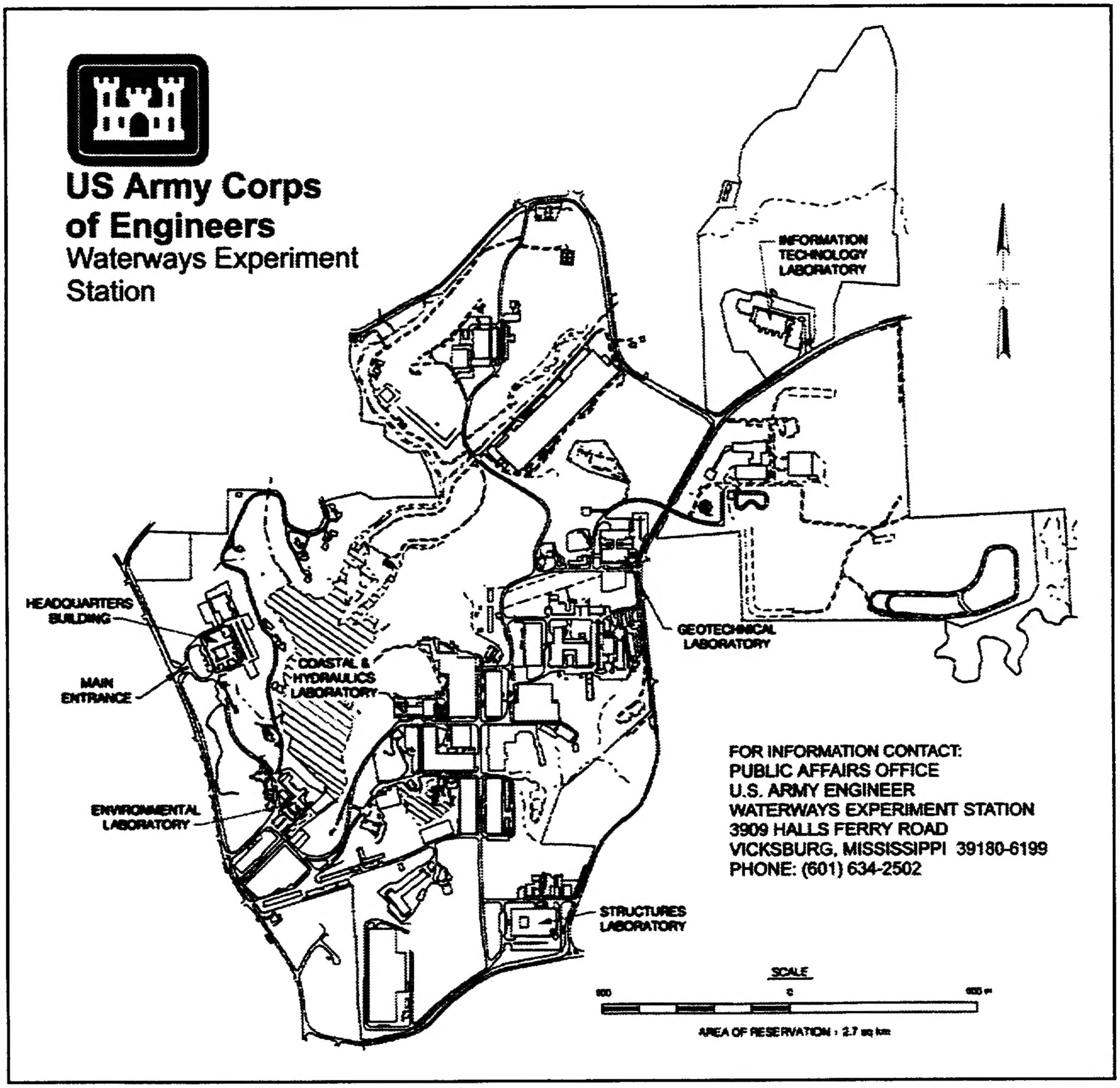

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Contents

Preface

The hydrodynamic field investigation reported herein was conducted by the U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, MS, from 22 June 1995 through 19 August 1995, to provide the necessary data for development of the three-dimensional hydrodynamic model of the San Juan Bay and Estuary System in Puerto Rico. This field study was one component of the overall effort to develop and apply a linked hydrodynamic and water quality model of the San Juan Bay and Estuary System. This effort was funded by the U.S. Environmental Protection Agency (USEPA), National Estuary Program, through the U.S. Army Engineer District, Jacksonville. Mr. Mitch Granat was the study manager at the Jacksonville District and Ms. Susan Osofsky was the contract manager at the USEPA, Region II. The WES liaison for the field study was Dr. R. Kennedy of the Environmental Laboratory (EL) and Dr. M. Dortch, EL, was the overall WES study manager.

Personnel of the WES Coastal and Hydraulics Laboratory (CHL), Hydraulic Analysis Group (HAG), performed the work under the general supervision of Messrs. James R. Houston, Director, CHL; and Charles C. Calhoun, Jr., Assistant Director, CHL. The data collection program was designed by Messrs. T.L. Fagerburg, H.A. Benson, and T.C. Pratt, HAG. Data reduction was performed by Mrs. C.J. Coleman and Mr. Fagerburg, HAG. Laboratory analysis of water samples was performed by Mr. Doug Brister of the Sedimentation Engineering and Dredging Group, Estuaries and Hydrosciences Division, CHL. This report was prepared by Mr. Fagerburg.

At the time of publication of this report, Commander of WES was COL Robin R. Cababa, EN. Dr. Robert W. Whalin was the Director.

Conversion Factors, Non-SI to SI Units of Measurement

Multiply	By	To Obtain
cubic yards	0.7645599	cubic meters
feet	0.3048	meters
inches	25.4	millimeters
miles (U.S. statute)	1.609347	kilometers

1 Introduction

Background

The San Juan Bay Estuary System, a relatively large island estuary, consists of an inter-connected system of bays, canals, and lagoons that are connected to the Atlantic Ocean (see Figure 1). The estuary of San Juan Bay has three outlets to the sea and is composed of many different geographical elements. The system includes areas of six different municipalities within the San Juan metropolitan area.

The system starts in the extreme west with San Juan Bay and Harbor. The bay is located within the jurisdictions of the municipalities of Cataño, Guaynabo, Toa Baja, and San Juan. The bay has approximately 6.5 miles of coastline and is highly developed. Along the north coast of the bay is the San Antonio Canal, which is the connection between the bay and Condado Lagoon. The Condado Lagoon measures approximately 3/4 of a square mile in area. The lagoon is influenced almost completely by the ocean through its northern outlet located in the area known as El boquerón. This canal measures approximately 3.75 miles long with a width that varies from 6 ft during low tide at some points to 300 ft near the Constitution Bridge. The average depth is approximately 4 ft. The west end of Martin Peña Canal has been improved by dredging and bulkheading with a 10-ft-deep by 200-ft-wide channel for the "Acua-Expreso" ferry mass transit project. The east end of Martin Peña connects to the next section of the system, San José Lagoon.

Hydrologically, the lagoon is divided into two sections, Corozos Lagoon and San José Lagoon. These two areas have a surface area of approximately 1,129 acres and are the farthest points from ocean entrances and the effects of tidal hydrodynamics. There is no connection of these lagoons with the ocean. Suárez Canal is located near the southeast end of the San José Lagoon.

Suárez Canal measures approximately 2.4 miles long and connects San José Lagoon with the Torrecillas Lagoon and Piñones Lagoon. Torrecillas Lagoon and Piñones Lagoon are connected by a very small canal. The

Torrecillas Lagoon is connected to the Atlantic Ocean by Boca de Cangrejos. Torrecillas has an approximate surface area of 608 acres and is surrounded by mangrove forest. Piñones Lagoon is found to the east of Torrecillas Lagoon, and is located in the midst of the 10,000-acre State Forest of Piñones.

Freshwater inflows to the system of the San Juan Bay Estuary include the Puerto Nuevo River, Juan Mendez Creek, San Anton Creek, Blasina Creek and Malaria Channel, various storm water pump stations, as well as surface water runoff and other indirect sources.

The system is located in an area that is significantly degraded and threatened due to an increase in anthropogenically-generated waste. The area surrounding San Juan Bay Estuary is home to approximately 630,000 people and is host to a large tourist population. San Juan and surrounding areas can be characterized by rapid social and economic development, which has contributed greatly to the extremely large waste load the system receives. The health of the estuarine system is threatened by many problems. Potentially, the worst problems are toxic and pathogenic contamination, loss of habitat, marine debris, changes in living resources, and solid waste.

The study of circulation and salinities in the San Juan Bay Estuary System is a complex issue. A number of physical processes operate in the estuary and their relative importance can vary both spatially and temporally. Bathymetry and geometry of the estuary, astronomical tide-induced currents, wind-induced circulation, density variations and resulting gravitational-induced currents, and freshwater inflow are major factors determining estuary-wide circulation and salinity patterns.

Typical tide ranges for the San Juan Bay Estuary system range from 1.0 - 2.0 ft to below 0.1 ft in the interior portions of the system. The purpose of the modeling project is to develop a tool for assessing alternative plans in the Comprehensive Conservation and Management Plan (CCMP) for the improvement of circulation and water quality within the San Juan Bay Estuary System.

Purpose

The purpose of the San Juan Bay Estuary hydrodynamic monitoring program was to provide the necessary boundary condition, initial condition, and verification data for a comprehensive hydrodynamic model of the San Juan Bay Estuary System of connecting lagoons and canals. The purpose of this report is to provide a permanent record of the instrumentation and techniques employed during the field investigation and to make the data available for use. Another effort was devoted to the collection of water quality data to support

the water quality model of this system. The water quality data are documented in WES Miscellaneous Paper EL-96-9[1]

Scope

This report presents representative results of the field investigation of the San Juan Bay Estuary System that was conducted from 22 June 1995 through 19 August 1995. Measurements consisted of the following:

Short-term measurements (17-19 August 1995):

a. Current speed and direction at six ranges.
b. Salinity profiles at each of the ranges.
c. Water Samples at each of the ranges.
d. Water-level fluctuations, fixed-depth current velocities and salinity at long-term monitoring stations.

Long-term measurements (22 June-19 August 1995):

a. Water level monitoring at twelve locations.
b. Salinity measurements at each of the water level monitoring locations.
c. Salinity measurements at 0.8 depth at five locations.
d. Fixed-depth current speed, direction, and salinity at five locations.

This report describes the field investigation equipment and methods used to collect the data, presents representative results of the data reduction efforts, and summarizes the results of these efforts.

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[1] Kennedy, R. H. (1995). "San Juan Bay and estuary study: Water quality data collection," Miscellaneous Paper EL-96-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

2 Data Collection Equipment and Program

Data were collected in the San Juan Bay Estuary on 17-19 August 1995 as part of the short-term data collection program, which was concurrent with the long-term data collection program that began on 22 June 1995 and extended to 19 August 1995. During the data collection periods, water level recorders, moored current meters, and salinity recorders were in place continuously. As part of the short-term program, boat transect profile measurements of current speed and direction were obtained using a boat-mounted Acoustic Doppler Current Profiler (ADCP) as described in Appendix A. In addition, water samples were collected for quality control of salinity concentrations. The short- and long-term data collection efforts are described in further detail in subsequent sections of this report. Appendix A provides detailed information on the types of data collection equipment used in sampling efforts.

Water-Level Measurements

During the San Juan Bay field investigation, instruments were deployed for monitoring of water levels. These instruments are identified on the location map (Figure 2) as locations S1.0 - S12.0. Equipment type, parameters measured, depth of deployment, and latitude/longitude are described in Table 1. Water-surface elevations were monitored using Environmental Devices Corporation (ENDECO) model 1029 and 1152 SSM electronic water level recorders, as described in Appendix A. The ENDECO 1152 SSM recorder also recorded near-surface salinity concentrations. These instruments (1152's) were deployed at all locations except S4.0 and S5.0. At these two locations, ENDECO 1029's were deployed and recorded only water levels.

Fixed-Depth Current Speed, Direction, and Salinity

Fixed-depth current speed, direction, and salinity measurements were recorded using ENDECO model 174 SSM current meters similar to that described in the section on recording velocity meters of Appendix A. At each location (S1.0, S3.0, S5.0, S8.0, and S10.0), a single meter was deployed. Each meter was positioned at 0.8 of depth, as referenced to the location depth at low tide levels. Instrument locations are described in relationship to depth of deployment and latitude/longitude in Table 1. The sampling interval of these recording current meters was 15 min.

Salinity Measurements

The salinity concentrations at six locations (S1.0, S2.0, S4.0, S5.0, S7.0, and S10.0), other than the water level recorders and fixed-depth current meters, were recorded with the Hydrolab Datasonde 3 water quality data logger, as described in the "Salinity Measurements" section of Appendix A. These instruments were deployed in areas relatively close to the water level deployment locations and in water depths ranging from 7.0 - 12.0 ft. The instruments were positioned between 0.8-0.9 of depth. The meters were suspended vertically at these depths on a moored cable and heavy weight arrangement similar to that shown in Appendix A. A total of six deployment locations were chosen for both the intensive survey and long-term field investigation. They are designated as stations S1.0, S2.0, S4.0, S5.0, S7.0, and S10.0, as shown in Figure 2. Instrument locations in relationship to depth of deployment and latitude/longitude are described in Table 1. The sampling interval for these salinity recorders was 15 min.

Data Collection Range Locations

For the intensive data collection survey during 17-19 August 1995, the current speed and direction data collection ranges in the connecting canals were selected to yield the information most applicable to the numerical model study. The ranges are identified as R1.0, R2.0, R3.0, R4.0, R5.0, and R6.0. The general locations of these ranges are shown in Figure 3.

Boat Procedures

Prior to the beginning of the survey, the boats were assigned to data collection ranges. Boat 1 monitored ranges R1.0 - R3.0, in the western part of the system, and boat 2 monitored ranges R4.0 - R6.0, in the eastern part of the system. The boat moved into position at the same starting point for each range to begin the transect of the data collection range and ended at the same ending point. The data at each station were obtained approximately on an hourly basis

throughout each data collection day. The time interval between successive transects depended upon the distance of travel between each range and the length of each transect. Following the boat transect of the data collection range, a midchannel vertical profile of salinity concentrations was obtained by lowering and raising a Datasonde 3 Hydrolab over the side of the boat, stopping at selected depths to allow the sensor to stabilize before recording the data. The current speed and direction data from the ADCP were recorded electronically on a computer. The salinity profile data were recorded by hand on data log sheets.

Salinity Water Samples

Water samples were collected at each data collection range near the surface, approximately 2.0 ft below the water surface. These water samples provided a field check of the salinity readings from the Hydrolab.

Laboratory Analysis of Water Samples for Salinities

Individual water samples collected during the intensive survey were analyzed for salt content in the laboratory at WES. The analysis techniques used are described in the "Laboratory Equipment and Sample Analysis" section of Appendix A.

Long-term Field Investigation Equipment Service Procedures

At the beginning of the long-term data collection effort, all water level, salinity, and velocity equipment were cleaned and checked for proper operation, new batteries were installed, and new recording media were installed where applicable. Biological fouling of the salinity and water level sensors is a typical problem in long-term deployment situations, particularly in warm shallow waters where marine life proliferates. Another major problem encountered with long-term unattended deployments is the accidental destruction of the submerged instruments and moorings by commercial fishing activities, local vessel traffic, and/or vandalism. The San Juan Bay area contains a very busy commercial fishing, transportation, and recreational industry. Various means were employed to protect the instruments from vandalism and accidental encounters with local navigation traffic. Private docks were utilized, where available, for the water level and salinity recorders. The fixed-depth current meters were deployed at a depth and location safely outside of interference by commercial and recreational traffic in the main channels. They were deployed using submerged floats and were tethered by cable or rope to a stationary object (e.g., tree or piling) near the shore. A typical deployment is shown in Appendix A. However, despite these precautions , one ENDECO 174 current meter (S10.0) was lost and one ENDECO 1152 water level recorder (S12.0) was damaged by vandalism. The

loss of the current meter was unfortunate because with it went all of the data from the first day of deployment. The water level recorder operated approximately one month before the vandalism occurred.

Quality Control/Data Quality Assurance

During the instrument deployment, techniques were employed to provide information on the quality of the data being obtained. The data collected included calibration verification (both prior to deployment and following retrieval) of the salinity meters using a known calibration standard at a temperature of 25° C. The information provided a determination of the changes to the relative accuracy of the instruments due to the effects of biological growth on the salinity sensors.

3 Data Presentation

Short-Term Data Collection

Water surface measurements

Time-history plots of water-surface elevation data observed during the 17-19 August 1995 intensive data collection efforts are shown in Plates 1-29. All water level recorders appeared to function properly during the survey period, except S7.0, which had an electronic malfunction, and S12.0, which was vandalized.

The data from location S1.0 were used as a reference station for comparison with the data from the other stations in order to estimate tidal phase and range differences between the entrance and the interior reaches of the San Juan Estuary. This comparison illustrated that observed tide ranges were small, with the maximum tidal range, 1.6 ft, observed at S1.0, S2.0 , S3.0 and S5.0 on 19 August 1995. The comparison also showed that the maximum time lag of +4.0 hr occurred at locations S6.0 and S11.0, using S1.0 as the reference location, at the time of high water. The high-water time lag and the maximum range of tide between S1.0 and the other water level recording locations are summarized in the following table for the short-term data collection period.

Location	S1.0	S2.0	S3.0	S4.0	S5.0	S6.0	S7.0	S8.0	S9.0	S10.0	S11.0	S12.0
Range,ft	1.6	1.6	1.6	1.5	1.6	0.1	--	1.3	1.3	1.3	0.3	--
Phase,hr	0	+.25	+.12	+.25	+.4	+4.0	--	+1.0	-0.25	+.75	+4.0	--
-- = Recorder malfunction; no data available												

Velocity measurements

Plates 30-155 are representative time-history plots of the ADCP velocity magnitudes obtained during the 17-19 August 1995 data collection period. Ebb and flood directions in the plots were determined from the direction of the current relative to the orientation of the range. The ebb and flood directions were ±90 deg from the azimuth orientation of the data collection range. The current directions that indicated ebb flow were identified with a negative value of current speed.

The maximum velocity was found to occur at range R1.0, a bottom measurement of 2.2 ft/sec during both ebb and flood flow. Maximum ebb and flood velocities and depths (surface, middepth, or bottom) where the velocity was observed to occur are summarized in the following table for the short-term data collection period.

	VELOCITY MAGNITUDE, fps					
LOCATION	R1.0	R2.0	R3.0	R4.0	R5.0	R6.0
MAX. EBB	2.2	0.2	0.2	0.6	1.0	0.8
S - SURFACE M- MIDDEPTH B - BOTTOM	B	S	S	S	B	S M B
MAX. FLOOD	2.2	0.6	0.4	1.0	1.0	1.0
S - SURFACE M- MIDDEPTH B - BOTTOM	B	B	B	B	S M B	S

Weather played a significant role during the data collection effort. The data at each transect were obtained approximately on an hourly basis throughout each data collection day. The time interval between successive transects depended upon the distance of travel between each range and the length of each transect. During the data collection period, daily thunderstorms with high sustained winds and heavy rains made data collection difficult and unsafe due to severe wave action and lightning strikes in the open areas of the San Juan Bay Estuary System, especially in the middle of San Juan Bay and Torecilla Lagoons. At these times, data collection was temporarily delayed until the weather system passed.

Freshwater inflow from storm water runoff in the Puerto Nuevo River contributed to the flow in the western end of the Martin Peña canal during the August data collection effort. However, due to the large size of San Juan Bay, the increased freshwater inflow at the time of the survey did not cause large nontidal variations in the magnitude and direction of the currents within

San Juan Harbor. There were no significant eddies or unusual flow circulation patterns observed at any stations. Well-defined depth gradients of velocity were only evident at data collection range R1.0.

Fixed-depth velocity measurements

Time-history plots of the current speeds from the fixed-depth current meters for the 17-19 August 1995 period of the intensive data collection effort are shown in Plates 156-159. The maximum current speed observed (0.68 ft /sec) occurred at meter location S3.0, as indicated in Plate 156. The magnitudes and directions of the current speeds observed for all the current meter deployment locations generally agreed very closely with the information obtained from nearby ADCP velocity data collection ranges. The ebb and flood directions shown in the fixed-depth current meter time-histories, as indicated by "-" and "+" values, respectively ,were determined by the same techniques used for the ADCP velocity data. These current meters are prone to fouling by submerged floating debris (ie. kelp, plastic bags, fishing line, etc.), which float into the impeller housing and prevent the impeller from rotating. Occasionally the debris are shed by the meter when the flow direction reverses, as shown in Plate 157. However, this is not always the case and the meter ceases to operate properly, as can be seen in Plate 159. The observed maximum ebb and flood velocity magnitudes for the fixed-depth current meters from 17-19 August 1995 are summarized in the following table.

	VELOCITY MAGNITUDE, fps			
Location	S1.0	S3.0	S5.0	S8.0
Ebb	0.24	0.44	0.10	0.0*
Flood	0.20	0.69	0.10	0.0*
* Equipment malfunctioned or clogged with debris				

Salinity measurements

Time-history plots of salinity data during the 17-19 August 1995 data collection period for the water-level recorders, fixed-depth current meters, and the Datasonde instruments are shown in Plates 160-176. The observed maximum salinities for the data collection locations are summarized in the following table for the short-term data collection period.

		SALINITY CONCENTRATION, PPT (17-19 August 1995)										
LOCATION		S1.0	S2.0	S3.0	S4.0	S5.0	S6.0	S7.0	S8.0	S9.0	S10	S11
WATER LEVEL REDORDER	MAX	34.4	34.8	34.6	—	—	17.9	*	30.0	34.0	31.8	30.9
	MIN	31.9	33.6	33.0	—	—	15.8	*	27.0	32.3	25.6	26.0
FIXED-DEPTH CURRENT METER	MAX		—	32.5	—	30.2	—	—	24.3	—	X	—
	MIN		—	28.0	—	29.6	—	—	21.1	—	X	—
DATASONDE 3	MAX	35.9	33.8	—	33.0	35.0	—	26.7	—	—	—	—
	MIN	34.2	31.9	—	31.8	34.6	—	26.7	—	—	—	—

— NO INSTRUMENT INSTALLED AT THIS LOCATION; X = INSTRUMENT LOST, NO DATA RETRIEVED
* INSTRUMENT MALFUNCTION

Biological fouling of the salinity sensors was due to the length of time the instruments were deployed, particularly in warm shallow waters where marine life proliferates. A decrease in salinity readings, due to biological fouling, was observed in the recorded data of several of the water level recorders and the fixed-depth current meter deployments. Utilizing salinity profile data from each boat, obtained during the 17-19 August 1995 period (Tables 2-7), adjustments were made to the data to show the overall effect of the fouling. These adjustments, if necessary, are illustrated in the plates.

Tables 2-7 represent the salinity profile data obtained at each data collection range during the 17-19 August 1995 data collection period. General observations on the salinity data indicated significant differences in the maximum near-surface salinity values in the canals. Salinity values at the profile locations at Martin Peña Canal (Ranges R2.0 and R3.0), Suárez Canal (Ranges R4.0 and R5.0), and Piñones Lagoon (Range R6.0) indicate that the water column were poorly mixed due to the extremely low velocities within the canals. Range R1.0, in the San Antonio Canal, was observed to have little or no significant salinity stratification (less than 3 ppt over the 40-ft depth profile). Ranges R2.0 - R6.0 were observed to have considerable vertical stratification or variation of salinities over the profiled depth. Ranges R2.0 and R3.0, in the Martin Peña Canal, were observed to have a lens of nearly fresh water at or near the surface (within the upper 2 ft) apparently due to freshwater runoff during afternoon rain showers. Also indicated in the tables are the salinity concentrations obtained from laboratory analysis of the quality control salinity samples taken near the surface at various times during each day of data collection. Slight variations can be seen between the salinity meter reading and the sample analysis, but, in general, agreement between readings is generally less than 1 ppt difference.

Long-Term Field Investigation

Water-level measurements

Water-level elevation data for the long-term field investigation, 22 June-19 August 1995, are plotted in Plates 177-198. As with any long-term deployment of instrumentation for data collection, periods of equipment malfunction occurred. The majority of the water-level recorders functioned properly during the data collection period. The exceptions were the instruments at locations S4.0, which developed a calibration drift, and S7.0, which malfunctioned completely.

The data display the spring and neap tide extremes and large semidiurnal inequalities for the system during the period of the study. The zero datum indicated in the plots is an arbitrary datum and is not referenced to a specific mlw elevation. The observed maximum tidal ranges and time lags for location S1.0 from 22 June-19 August 1995 are summarized in the following table.

	Maximum Observed Tide Conditions (22 June - !9 August, 1996)											
Location	S1.0	S2.0	S3.0	S4.0	S5.0	S6.0	S7.0	S8.0	S9.0	S10.0	S11.0	S12.0
Range,ft	2.4	2.4	2.4	2.4	2.1	0.2	--	2.0	2.1	2.0	.4	.4
Phase,hr	0	+.25	0	+.5	+.5	+4.0	--	+1.5	+.5	+.5	+3.25	+3.75
-- Equipment malfunctioned												

Fixed-depth velocity measurements

Time-histories of the current speeds and salinities during the long-term data collection period (22 June-19 August 1995) are shown in Plates 199-206. Following the intensive data collection effort, the locations were checked and one meter deployment (S10.0) was found to be missing as a result of dredging operations within the entrance to Torrecilla Lagoon. Another problem often encountered was that of the impeller being fouled by floating debris. The meter would begin functioning properly when the object became dislodged. Examples of these problems were seen at locations S3.0 (Plate 201) and S8.0 (Plates 205 and 206).

Peak magnitudes of current speeds within the connecting canals ranged from 0.57 to 0.68 ft/sec. It should be noted that the ebb flow direction (-) for stations S4.0 and S5.0 in the Martin Peña Canal indicates flow toward San Juan Bay and the flood flow direction (+) is toward San José Lagoon. In Suárez Canal (S2.0 and S8.0), the ebb (-) flow is toward the Torrecilla

Lagoon. Observed maximum ebb and flood velocity magnitudes for the fixed-depth current meters from 22 June-19 August 1995 are summarized in the following table.

	MAXIMUM OBSERVED VELOCITY MAGNITUDE, fps			
Location	S1.0	S3.0	S5.0	S8.0
Ebb	0.6	0.5	0.2	0.4
Flood	0.6	0.7	0.2	0.6

Salinity measurements

Salinity concentrations for the period 22 June-19 August 1995 were recorded continuously at the locations of the water level recorders, fixed depth current meters (with conductivity sensors), and the Datasonde 3 water quality recorders. The salinities recorded by these three types of instruments are shown in Plates 207-239.

Biological fouling of the salinity sensors is one of the major contributors to the differences seen in the salinity profile values and the sensor recordings. When fouling is occurring, salinity concentration readings generally begin a decrease within 1-2 weeks of initial deployment. Typically, the change is a very gradual downward drift of the salinity value as growth develops. This change is due to marine growth affecting the calibration of the instrument. Adjustments were made to some of the actual data to indicate the relative change caused by the effects of biological fouling and can be seen in many of the plates where the fouling had a significant effect on the data. Salinity concentrations in the south part of San Juan Bay (station S2.0) ranged from 34-35 ppt. In the Martin Peña Canal (stations S4.0 and S5.0), the salinity concentrations ranged from 5-34 ppt. In the Suarez Canal, (stations S7.0 and S8.0), concentrations ranged from 13-33 ppt. In San Jose Lagoon (S6.0), concentrations ranged from 16 - 28 ppt. The observed maximum salinities for the data collection locations are summarized in the following table for the long-term data collection period.

		SALINITY CONCENTRATION, PPT										
LOCATION		S1.0	S2.0	23	S4.0	S5.0	S6.0	S7.0	S8.0	S9.0	S10	S11
WATER LEVEL REDORDER	MAX	35.9	35.7	36.1	—	—	28.1	*	32.0	32.2	35.9	32.0
	MIN	31.4	32.8	31.6	—	—	15.8	*	15.0	31.9	25.6	17.5
FIXED-DEPTH CURRENT METER	MAX	37.5	—	34.4	—	30.7	—	—	28.2	—	X	—
	MIN	32.4	—	27.8	—	28.7	—	—	21.6	—	X	—
DATASONDE 3	MAX	36.3	35.8	—	35.7	35.2	—	29.1	—	—	—	—
	MIN	33.4	31.3	—	29.6	31.3	—	24.7	—	—	—	—

— NO INSTRUMENT INSTALLED AT THIS LOCATION; X = INSTRUMENT LOST, NO DATA RETRIEVED
* INSTRUMENT MALFUNCTION

4 Summary

The data presented herein were collected from the intensive survey (17-19 August 1995) and a 2-month, long-term sampling effort (22 June-19 August 1995) conducted within the San Juan Bay Estuary System. The following observations were made:

a. During the short-term data collection period (17-19 August 1995), the maximum water-level fluctuation observed was 1.6 ft at S1.0, S2.0, S3.0, and S5.0.

b. The maximum one-cycle tide range observed at location S1.0 was 2.4 ft and occurred on 12 July 1995. At this same time, the maximum one-cycle tide range observed in the connecting canals was 2.4 ft at S4.0, 2.1 ft at S5.0, and 2.0 ft at S8.0. Maximum tide ranges in the San José Lagoon (S6.0) and Piñones Lagoon (S12.0) were 0.2 ft and 0.4 ft, respectively.

c. Maximum velocities observed for the short-term data collection period occurred at the strength of ebb of the tidal cycle. The maximum recorded velocities were generally less than 1.0 ft/sec. Velocities obtained from the fixed-depth current meters were found to be in general agreement with those values measured from the Acoustic Doppler Current Profile data collection equipment.

d. Salinity concentrations obtained during the short-term and long- term data collection periods indicated that the low velocities of the bay and connecting lagoons created a partly mixed salinity environment.

e. Little or no tidal exchange of the interior water of the lagoons and canals was evident from the data.

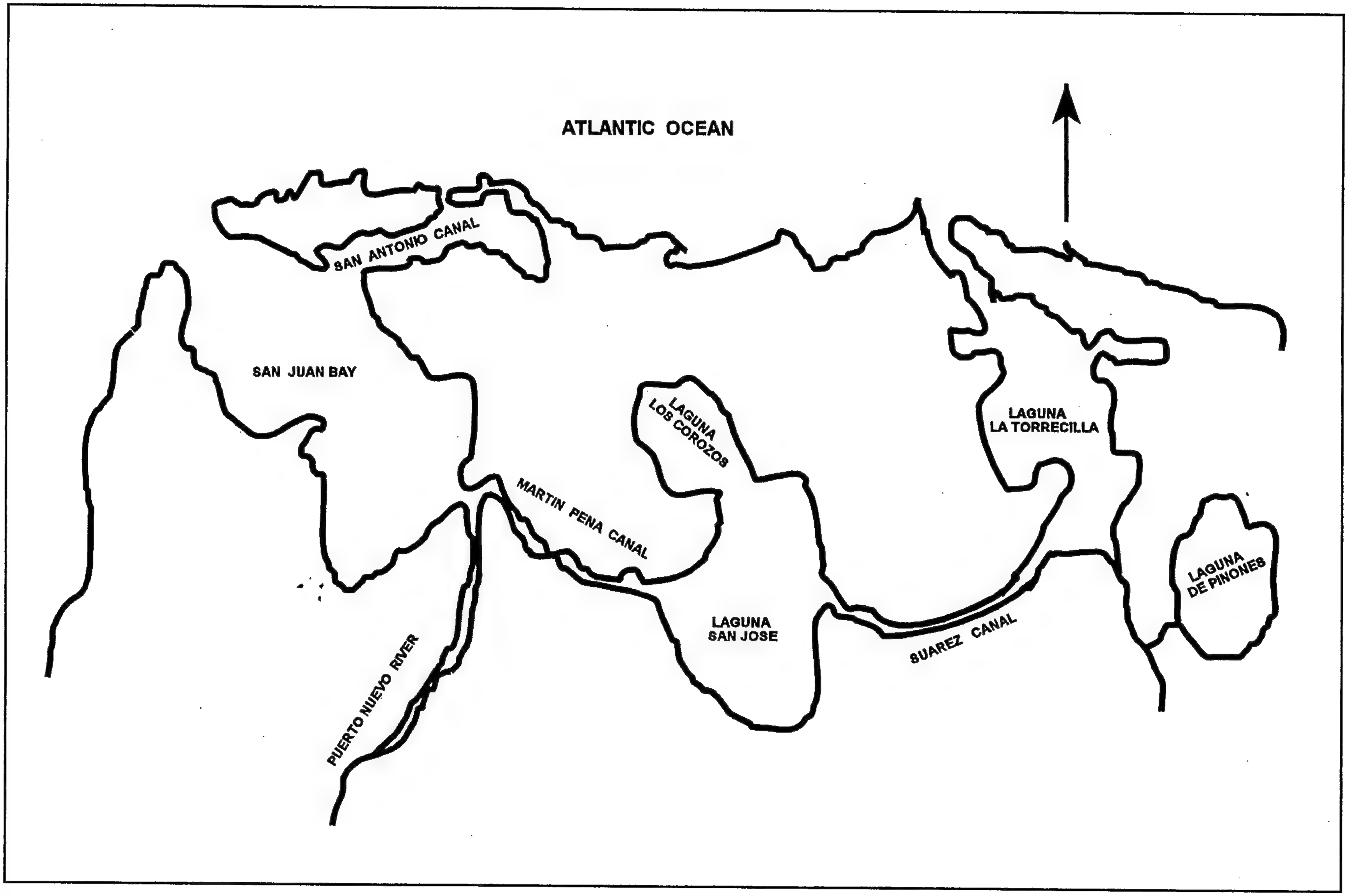


Figure 1. San Juan Bay Estuary System

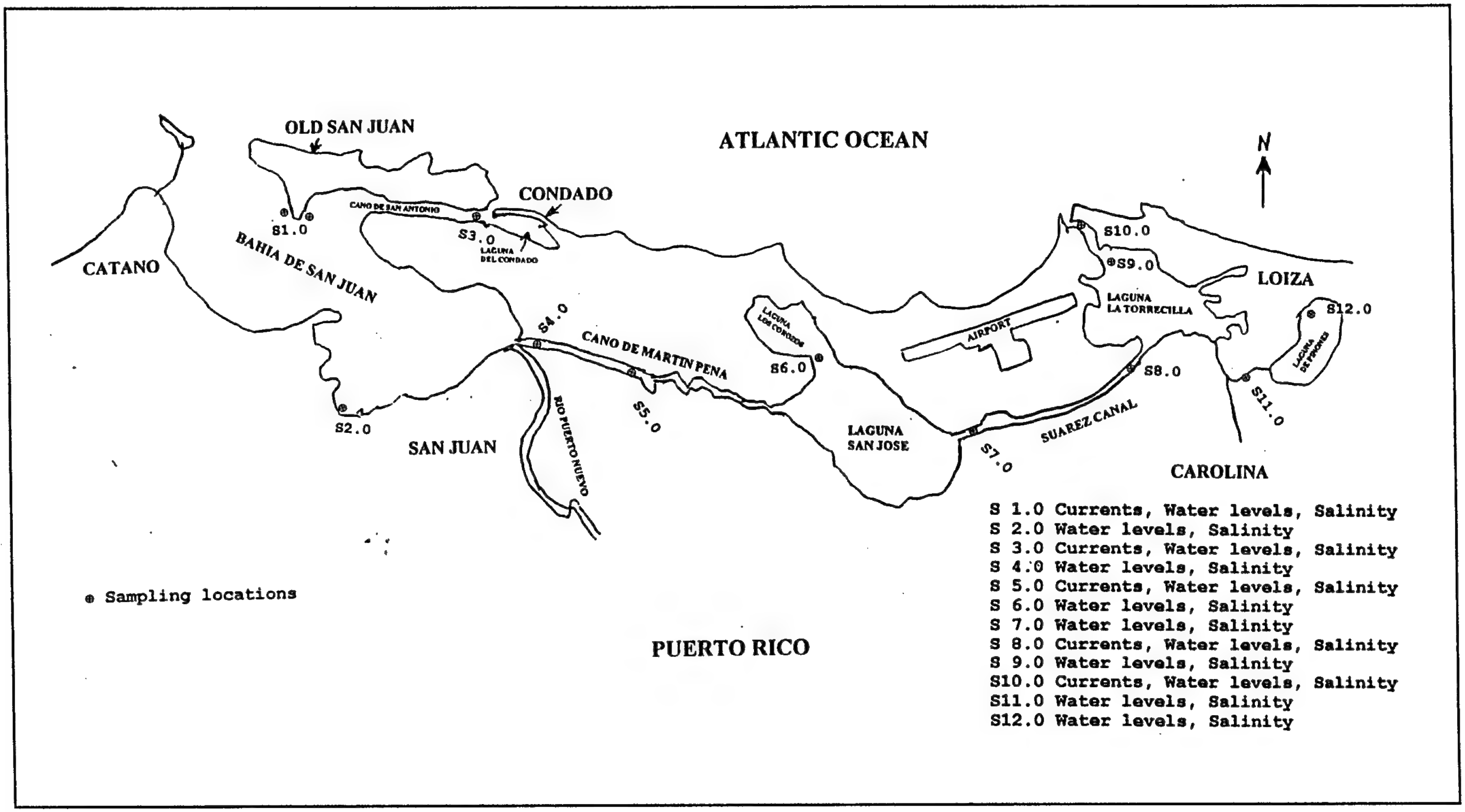


Figure 2. Location map, San Juan Bay and Estuary

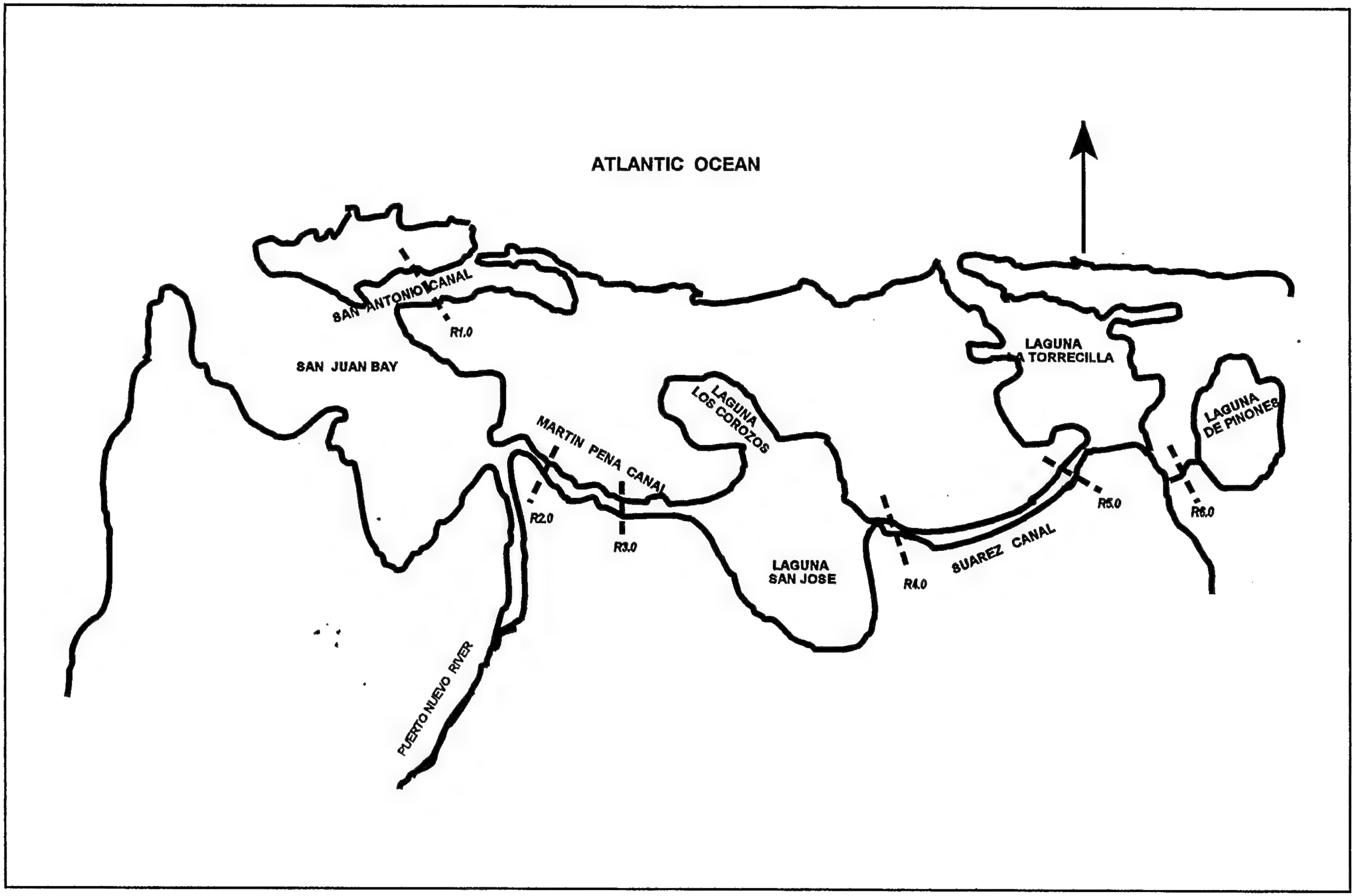


Figure 3. Data collection range locations

Table 1 **Long-term Monitoring Equipment Types and Locations**					
Station No.	Instrument Type	Data Collected	Depth of Deployment	Latitude/ Longitude	Period of Deployment
S1.0	ENDECO 1152	Water levels Salinity	Near-surface	18° 27' 34" N 66° 06' 59" W	06/25/95 - 08/20/95
	ENDECO 1029	Water-levels	Near-surface	"	"
S1.0	ENDECO 174	Velocity Direction Salinity	80% of Depth	18° 27' 32" N 66° 07' 08" W	"
	DATASONDE 3	Salinity	80% of Depth	"	"
S2.0	ENDECO 1152	Water levels Salinity	Near-surface	18° 25' 39" N 66° 06' 30" W	"
	DATASONDE 3	Salinity	80% of Depth	"	"
S3.0	ENDECO 1029	Water-levels	Near-surface	18° 27' 32" N 66° 05' 17" W	"
	ENDECO 174	Velocity Direction Salinity	80% of Depth	"	"
S4.0	ENDECO 1029	Water-levels	Near-surface	18° 26' 13" N 66° 04' 36" W	"
	DATASONDE 3	Salinity	80% of Depth	"	"
S5.0	ENDECO 1029	Water-levels	Near-surface	18° 26' 02" N 66° 03' 48" W	"
	ENDECO 174	Velocity Direction Salinity	80% of Depth	"	"
	DATASONDE 3	Salinity	80% of Depth	"	"
S6.0	ENDECO 1152	Water-levels Salinity	Near-surface	18° 26' 11" N 66° 02' 06" W	"
S7.0	ENDECO 1152	Water-levels Salinity	Near-surface	18° 25' 26" N 66° 00' 33" W	"
	DATASONDE 3	Salinity	80% of Depth	"	"

Table 1 (Concluded)

Station No.	Instrument Type	Data Collected	Depth of Deployment	Latitude/ Longitude	Period of Deployment
S8.0	ENDECO 1152	Water-levels Salinity	Near-surface	18° 26' 12" N 65° 58' 56" W	06/25/95 - 08/20/95
	ENDECO 174	Velocity Direction Salinity	80% of Depth	"	"
S9.0	ENDECO 1152	Water-levels Salinity	Near-surface	18° 27' 27" N 65° 59' 11" W	"
S10.0	ENDECO 1152	Water-levels Salinity	Near-surface	18° 27' 27" N 65° 59' 30" W	"
	ENDECO 174	Velocity Direction Salinity	80% of Depth	"	"
	DATASONDE 3	Salinity	80% of Depth	"	"
S11.0	ENDECO 1152	Water-levels Salinity	Near-surface	18° 26' 03" N 65° 57' 47" W	"
S12.0	ENDECO 1152	Water-levels Salinity	Near-surface	18° 26' 28" N 65° 57' 27" W	"

Table 2
Salinity Profile Data Collection Range R1.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/17/95	0615	39	32.4		08/17/95	1128	40	34.4
	0615	35	32.4			1129	36	34.5
	0616	31	32.4			1130	32	34.4
	0617	27	32.4			1131	28	34.4
	0618	23	32.4			1131	24	34.4
	0619	19	32.3			1132	20	34.4
	0620	15	32.3			1133	16	34.4
	0621	11	32.3			1134	12	34.4
	0622	7	32.3			1135	8	34.4
08/17/95	0622	3	32.3			1136	4	34.4
					08/17/95	1136	2	34.4
08/17/95	0838	38	33.1					
	0838	34	33.1		08/17/95	1300	38	34.3
	0839	30	33.4			1301	34	34.4
	0840	26	33.4			1302	30	34.4
	0841	22	33.9			1303	26	34.4
	0842	18	33.9			1304	22	34.5
	0843	14	33.9			1305	18	34.5
	0844	10	33.9			1306	14	34.5
	0845	6	34.0			1307	10	34.5
	0845	4	34.1			1308	6	34.6
08/17/95	0846	2	34.2 (35.25*)		08/17/95	1308	2	34.6

* = Water sample laboratory analysis

Table 2 (continued)
Salinity Profile Data Collection Range R1.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/17/95	1554	36	34.3		08/18/95	0747	38	31.2
	1554	32	34.3			0748	34	31.3
	1555	28	34.3			0749	30	31.3
	1556	24	34.3			0750	26	31.3
	1557	20	32.3			0750	22	31.3
	1558	16	32.3			0751	18	31.6
	1559	12	32.3			0752	14	31.7
	1600	8	32.3			0753	10	31.7
	1601	4	32.4			0754	6	31.7
08/17/95	1601	2	32.6 (*35.23)		08/18/95	0754	2	31.7
08/17/95	1724	38	34.1		08/18/95	0910	36	33.2
	1725	34	33.3			0911	32	33.2
	1725	30	33.3			0912	28	33.2
	1726	26	33.2			0913	24	33.2
	1726	22	33.2			0914	20	33.2
	1727	18	33.2			0914	16	33.2
	1727	14	33.2			0915	12	33.2
	1728	10	33.2			0916	8	34.1
	1728	6	33.2			0917	4	34.1
	1729	4	33.2		08/18/95	0917	2	34.1 (*35.02)
08/17/95	1729	2	33.2					

* = Water sample laboratory analysis

Table 2 (continued)
Salinity Profile Data Collection Range R1.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/18/95	1044	38	33.0		08/18/95	1608	36	34.5
	1045	34	33.0			1608	32	34.5
	1046	30	33.6			1609	28	34.5
	1047	26	33.6			1610	24	34.5
	1047	22	33.6			1610	20	34.5
	1048	18	33.7			1611	16	34.5
	1048	14	33.7			1611	12	34.5
	1049	10	33.7			1612	8	34.7
	1050	6	33.7			1623	4	34.7
08/18/95	1050	2	33.8		08/18/95	1613	2	34.7 (*34.92)
08/18/95	1258	36	32.8		08/19/95	0529	36	33.6
	1259	32	32.7			0530	32	33.7
	1300	28	32.8			0530	28	33.7
	1301	24	32.9			0531	24	33.6
	1301	20	32.9			0531	20	33.5
	1302	16	33.0			0532	16	33.5
	1303	12	33.0			0532	12	33.5
	1304	8	33.0			0533	8	33.5
	1305	4	32.8			0534	4	33.5
08/18/95	1305	2	33.0		08/19/95	0534	2	33.5 (*34.46)

* = Water sample laboratory analysis

Table 2 (continued)
Salinity Profile Data Collection Range R1.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/19/95	0656	34	34.4		08/19/95	1052	36	33.0
	0657	30	34.4			1053	32	33.4
	0658	26	34.4			1053	28	33.3
	0659	22	34.4			1054	24	33.2
	0700	18	31.3			1054	20	33.2
	0700	14	31.3			1055	16	33.2
	0701	10	31.6			1055	12	33.2
	0702	6	31.6			1056	8	33.2
08/19/95	0702	2	31.8			1057	4	33.2
					08/19/95	1057	2	33.2
08/19/95	0819	34	34.0		08/19/95	1451	36	34.4
	0820	30	34.0			1452	32	34.4
	0820	26	34.0			1452	28	34.4
	0821	22	33.9			1453	24	34.4
	0821	18	33.9			1453	20	34.4
	0822	14	33.9			1454	16	31.3
	0822	10	33.9			1454	12	31.3
	0823	6	33.9			1455	8	31.6
08/18/95	0823	2	33.9			1456	4	31.6
					08/19/95	1456	2	31.8

Table 2 (concluded)
Salinity Profile Data Collection Range R1.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/19/95	1602	34	33.0					
	1602	30	33.6					
	1603	26	33.6					
	1603	22	33.6					
	1604	18	33.7					
	1604	14	33.7					
	1605	10	33.7					
	1605	6	33.7					
08/19/95	1606	2	33.8 (*33.80)					

* = Water sample laboratory analysis

Table 3
Salinity Profile Data Collection Range R2.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/17/95	0716	12	27.9		08/18/95	0806	10	28.0
	0716	8	28.2			0807	8	27.2
	0717	4	25.0			0808	4	25.1
	0717	2	22.8		08/18/95	0808	2	22.8
08/17/95	0718	1	14.9 (*15.68)					
					08/18/95	0934	10	33.2
8/17/95	0918	10	25.5			0934	8	33.2
	0919	6	25.7			0935	4	32.1
	0919	4	25.7			0936	2	23.0
08/17/95	0920	2	19.5		08/18/95	0936	1	5.9 (*6.72)
8/17/95	1155	12	34.0		08/18/95	1131	10	29.9
	1156	8	31.5			1132	6	29.9
	1156	4	29.9		08/18/95	1132	2	28.2
08/17/95	1157	2	24.7					
					08/18/95	1421	10	27.2
8/17/95	1333	12	29.3			1422	6	27.1
	1334	8	29.2		08/18/95	1422	2	24.0
	1334	4	28.2					
08/17/95	1335	2	24.6		08/18/95	1632	10	33.2
						1633	6	32.9
8/17/95	1618	12	29.4			1634	2	26.1
	1619	8	29.6		08/18/95	1634	1	6.4 (*6.74)
	1619	4	27.6					
	1620	2	23.8					
08/17/95	1620	1	7.4 (*8.48)		* = Water sample laboratory analysis			

Table 3 (concluded)
Salinity Profile Data Collection Range R2.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/19/95	0555	10	27.6		8/19/95	1325	10	30.1
	0556	6	27.5			1326	6	29.4
	0557	4	18.4			1327	4	25.7
	0558	2	13.1		08/19/95	1327	2	15.0
08/19/95	0559	1	5.2 (*4.98)					
8/19/95	0722	10	28.4		8/19/95	1516	10	27.6
	0722	6	28.1			1517	6	27.6
08/19/95	0723	2	13.7			1518	4	27.0
						1519	2	13.9
					08/19/95	1519	1	7.0 (*7.60)
8/19/95	0905	10	24.0					
	0906	6	23.8		8/19/95	1623	10	29.9
	0907	4	21.1			1624	6	29.4
08/19/95	0908	2	15.4			1625	4	28.4
					08/19/95	1625	2	18.3
8/19/95	1114	10	32.3					
	1115	6	32.2					
	1116	4	31.8					
08/19/95	1116	2	11.2		* = Water sample laboratory analysis			

Table 4
Salinity Profile Data Collection Range R3.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/17/95	0740	12	29.6		08/18/95	0827	10	33.3
	0741	8	29.5			0827	6	33.1
	0742	4	25.8		08/18/95	0828	2	19.9
08/17/95	0742	2	22.8					
					08/18/95	1005	10	33.0
8/17/95	1008	12	33.9			1006	6	32.6
	1008	8	33.7			1007	2	15.4
	1109	4	32.3		08/18/95	1007	1	10.5 (* 10.08)
	1110	2	22.0					
08/17/95	1110	1	22.0 (*21.72)		08/18/95	1216	10	34.1
						1216	6	33.6
8/17/95	1219	12	34.4		08/18/95	1217	2	25.8
	1220	8	33.9					
	1221	4	33.3		08/18/95	1453	12	30.1
08/17/95	1222	2	24.0			1454	8	30.2
						1455	6	30.0
8/17/95	1356	12	31.8		08/18/95	1455	2	24.3
	1357	8	31.5					
	1358	4	31.0		08/18/95	1648	10	33.2
08/17/95	1359	2	28.9			1649	6	32.9
						1650	2	26.1
8/17/95	1636	12	29.9		08/18/95	1650	1	21.3 (* 20.38)
	1637	8	29.9					
	1638	4	29.7					
08/17/95	1639	2	25.5 (* 25.61)					

* = Water sample laboratory analysis

Table 4 (concluded)
Salinity Profile Data Collection Range R3.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/19/95	0618	10	29.8		8/19/95	1344	10	33.1
	0619	6	29.4			1344	6	30.6
	0620	4	20.9			1345	4	24.0
	0621	2	15.6		08/19/95	1346	2	8.3
08/19/95	0621	1	7.0 (* 7.76)					
					8/19/95	1534	10	31.2
8/19/95	0742	10	33.0			1534	6	30.9
	0743	6	32.4			1535	4	30.3
	0744	4	20.7			1536	2	18.6
08/19/95	0744	2	8.9		08/19/95	1537	1	9.2 (* 9.67)
8/19/95	0926	10	33.6		8/19/95	1637	12	29.7
	0927	6	32.8				8	29.4
	0928	4	21.1			1638	6	29.5
08/19/95	0928	2	8.5			1639	4	29.1
					08/19/95	1640	2	22.0
8/19/95	1132	10	33.6					
		6	33.0					
	1133	4	26.9					
08/19/95	1134	2	10.9					

* = Water sample laboratory analysis

Table 5
Salinity Profile Data Collection Range R4.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/17/95	0601	12	24.8		8/17/95	0917	12	25.0
	0602	10	24.4			0918	10	24.6
	0603	8	24.0			0919	8	24.0
	0604	6	20.1			0920	6	18.5
	0605	4	16.6			0921	4	15.7
	0606	2	14.9			0922	2	14.6
8/17/95	0607	1	14.4		8/17/95	0922	1	14.4
08/17/95	0718	12	24.9		08/17/95	1045	12	25.1
	0719	10	24.8			1046	10	24.6
	0720	8	23.5			1047	8	22.8
	0721	6	18.9			1048	6	18.8
	0722	4	15.5			1049	4	17.0
	0723	2	14.4			1050	2	14.5
08/17/95	0724	1	14.1 (* 14.23)		08/17/95	1050	1	14.0
8/17/95	0818	12	25.2		8/17/95	1218	12	24.3
	0819	10	25.0			1219	10	24.3
	0820	8	23.8			1220	8	23.6
	0821	6	20.8			1221	6	22.1
	0822	4	15.5			1222	4	15.1
	0823	2	14.8			1223	2	14.2
08/17/95	0824	1	14.6		08/17/95	1223	1	14.1

* = Water sample laboratory analysis

Table 5 (continued)
Salinity Profile Data Collection Range R4.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/17/95	1332	12	24.6		8/17/95	1716	12	24.4
	1333	10	24.5			1717	10	24.2
	1334	8	24.2			1718	8	24.0
	1335	6	21.3			1719	6	22.2
	1336	4	15.1			1720	4	16.5
	1337	2	14.4			1721	2	14.9
8/17/95	1337	1	14.1 (* 14.69)		8/17/95	1721	1	14.2
08/17/95	1444	12	24.7		8/18/95	0806	12	23.5
	1445	10	24.7			0807	10	23.5
	1446	8	24.5			0808	8	21.3
	1447	6	22.4			0809	6	16.0
	1448	4	16.1			0810	4	13.8
	1449	2	14.4			0811	2	13.7
08/17/95	1449	1	14.1		08/18/95	0811	1	13.7 (* 14.24)
8/17/95	1623	12	24.7		8/18/95	0902	12	23.7
	1624	10	24.5			0903	10	23.6
	1625	8	23.8			0904	8	20.6
	1626	6	20.0			0905	6	14.3
	1627	4	15.3			0906	4	14.0
	1628	2	14.6			0907	2	14.0
08/17/95	1628	1	14.6		08/18/95	0907	1	13.7

* = Water sample laboratory analysis

Table 5 (continued)
Salinity Profile Data Collection Range R4.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/18/95	0955	12	24.2		8/18/95	1409	12	24.2
	0956	10	24.1			1410	10	24.1
	0957	8	21.8			1411	8	23.5
	0958	6	15.9			1412	6	19.0
	0959	4	14.1			1413	4	14.9
	1000	2	13.6			1414	2	14.3
8/18/95	1001	1	13.6		8/18/95	1414	1	13.7
08/18/95	1120	12	24.4		8/18/95	1535	12	24.3
	1121	10	24.1			1536	10	23.9
	1122	8	22.6			1537	8	22.8
	1123	6	16.0			1538	6	17.6
	1124	4	14.6			1539	4	14.5
	1125	2	14.2			1540	2	14.1
08/18/95	1125	1	14.0		08/18/95	1540	1	13.7
8/18/95	1232	12	23.7		8/18/95	1631	12	23.9
	1233	10	23.7			1632	10	23.7
	1234	8	23.0			1633	8	22.9
	1235	6	18.2			1634	6	16.0
	1236	4	15.2			1635	4	14.4
	1237	2	14.3			1636	2	14.0
08/18/95	1237	1	13.9 (* 13.14)		08/18/95	1636	1	13.8

* = Water sample laboratory analysis

Table 5 (continued)
Salinity Profile Data Collection Range R4.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/19/95	0546	12	24.4		8/19/95	0856	12	24.4
	0547	10	24.0			0857	10	24.2
	0548	8	22.8			0858	8	23.1
	0549	6	17.5			0859	6	16.3
	0550	4	14.2			0900	4	14.4
	0551	2	13.6			0901	2	13.4
8/19/95	0551	1	13.1 (* 12.89)		8/19/95	0901	1	12.8
08/19/95	0645	12	24.4		8/19/95	0953	12	24.8
	0646	10	24.1			0954	10	24.6
	0647	8	23.5			0955	8	21.5
	0648	6	17.6			0956	6	17.1
	0649	4	14.0			0957	4	14.2
	0650	2	13.5			0958	2	13.8
08/19/95	0650	1	12.7		08/19/95	0958	1	13.2
8/19/95	0742	12	24.8		8/19/95	1124	12	24.7
	0743	10	24.7			1125	10	24.5
	0744	8	23.4			1126	8	23.0
	0745	6	16.6			1127	6	17.5
	0746	4	14.4			1128	4	14.1
	0747	2	14.1			1129	2	13.5
08/19/95	0747	1	13.2		08/19/95	1129	1	12.7

* = Water sample laboratory analysis

Table 5 (concluded)
Salinity Profile Data Collection Range R4.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/19/95	1239	12	24.2		8/19/95	1503	12	24.6
	1240	10	24.2			1504	10	24.3
	1241	8	23.5			1505	8	24.2
	1242	6	17.6			1506	6	16.6
	1243	4	13.9			1507	4	15.0
	1244	2	13.2			1508	2	13.7
8/19/95	1244	1	12.3		08/19/95	1508	1	12.7
08/19/95	1335	12	24.4		8/19/95	1604	12	24.4
	1336	10	24.3			1605	10	24.5
	1337	8	23.2			1606	8	23.9
	1338	6	16.6			1607	6	16.7
	1339	4	13.8			1608	4	14.7
	1340	2	13.7			1609	2	13.6
08/19/95	1340	1	12.9 (* 14.42)		8/19/95	1609	1	13.3

* = Water sample laboratory analysis

Table 6
Salinity Profile Data Collection Range R5.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/17/95	0629	16	32.6		8/17/95	0837	12	32.6
	0630	14	32.6			0839	10	32.4
	0631	12	32.5			0840	8	32.3
	0632	10	32.5			0841	6	31.6
	0633	8	32.3			0842	4	28.1
	0634	6	32.2		8/17/95	0843	2	19.4
	0635	4	31.6					
	0636	2	24.2		8/17/95	0951	16	32.5
8/17/95	0636	1	19.3 (* 16.64)			0952	14	32.6
						0953	12	32.6
08/17/95	0736	18	32.9			0954	10	32.4
	0737	16	32.9			0955	8	32.2
	0738	14	32.8			0956	6	31.7
	0739	12	32.7			0957	4	30.6
	0740	10	32.5			0957	3	22.2
	0741	8	32.3			0958	2	19.8
	0742	6	30.9		8/17/95	0958	1	19.0
	0743	4	29.6					
	0744	2	22.7		08/17/95	1102	10	32.5
08/17/95	0744	1	18.3			1103	8	32.1
						1104	6	31.0
						1105	4	28.3
						1106	3	24.0
						1106	2	19.7
					08/17/95	1107	1	19.6

* = Water sample laboratory analysis

Table 6 (continued)
Salinity Profile Data Collection Range R5.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/17/95	1234	16	31.7		08/17/95	1544	16	30.9
	1235	14	31.6			1545	14	30.9
	1236	12	31.5			1546	12	30.9
	1237	10	31.4			1547	10	30.8
	1238	8	30.2			1548	8	30.6
	1239	6	27.7			1549	6	30.8
	1240	4	26.0			1550	4	29.4
	1241	2	24.1			1551	2	26.2
08/17/95	1241	1	19.2		08/17/95	1551	1	24.3
					8/17/95	1642	18	31.8
						1643	16	31.5
						1644	14	31.6
						1645	12	31.6
						1646	10	31.2
8/17/95	1352	16	31.6			1647	8	31.1
	1353	14	31.6			1648	6	30.6
	1354	12	31.3			1649	4	30.0
	1355	10	31.0			1650	2	27.0
	1356	8	30.9		8/17/95	1650	1	21.0
	1357	6	28.6					
	1358	4	27.2					
	1359	2	24.8					
8/17/95	1359	1	21.5 (* 22.56)					

* = Water sample laboratory analysis

Table 6 (continued) Salinity Profile Data Collection Range R5.0							
Date	Time EST	Depth, ft	Salinity, ppt	Date	Time EST	Depth, ft	Salinity, ppt
8/17/95	1735	16	32.1	08/18/95	0925	4	26.9
	1736	14	31.9	.	0926	2	18.2
	1737	12	31.6	08/18/95	0926	1	16.4
	1738	10	31.4				
	1739	8	31.4	8/18/95	1039	14	31.5
	1740	6	30.8		1040	12	31.6
	1741	4	30.4		1041	10	31.5
	1742	2	24.2		1042	8	31.2
08/17/95	1742	1	20.8		1043	6	30.1
					1044	4	25.4
8/18/95	0821	18	31.5		1045	2	18.3
	0822	16	31.4	08/18/95	1045	1	17.7
	0823	14	31.4				
	0824	12	31.4	8/18/95	1153	18	31.7
	0825	10	31.2		1154	16	31.6
	0826	8	31.1		1155	14	31.6
	0827	6	30.8		1156	12	31.0
	0828	4	29.6		1157	10	30.9
	0829	2	19.2		1158	8	30.8
8/18/95	0829	1	16.1 (* 15.06)		1159	6	29.8
					1200	4	26.4
08/18/95	0920	14	31.8		1201	2	18.9
	0921	12	31.6	8/18/95	1201	1	18.2
	0922	10	31.5				
	0923	8	31.1				
08/18/95	0924	6	31.0				
* = Water sample laboratory analysis							

Table 6 (continued)
Salinity Profile Data Collection Range R5.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/18/95	1256	18	31.5		8/18/95	1558	8	30.0
	1257	16	31.5			1559	6	29.9
	1258	14	31.4			1600	4	26.7
	1259	12	31.4			1601	2	25.2
	1300	10	30.8		8/18/95	1601	1	19.9
	1301	8	30.2					
	1302	6	26.1		8/18/95	1650	16	30.9
	1303	4	34.1			1651	14	30.5
	1304	2	18.6			1652	12	30.4
08/18/95	1305	1	18.3			1653	10	29.8
						1654	8	29.3
8/18/95	1429	16	30.8			1655	6	29.2
	1430	14	30.5			1656	4	28.6
	1431	12	30.5			1657	2	25.6
	1432	10	30.2		8/18/95	1657	1	20.6
	1433	8	29.9					
	1434	6	28.3		8/19/95	0604	18	32.7
	1435	4	25.8			0605	16	32.6
	1436	2	24.3			0606	14	32.5
8/18/95	1436	1	20.6 (* 19.82)			0607	12	32.4
						0608	10	32.4
						0609	8	32.1
8/18/95	1553	18	31.1			0610	6	31.7
	1554	16	30.6			0611	4	31.4
8/18/95	1555	14	30.5			0612	2	27.0
					8/19/95	0612	1	14.8 (* 17.34)

* = Water sample laboratory analysis

Table 6 (continued)
Salinity Profile Data Collection Range R5.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/19/95	0703	18	32.6		8/19/95	0916	6	31.5
	0704	16	32.3			0917	4	29.7
	0705	14	32.3			0918	2	19.8
	0706	12	32.2		8/19/95	0918	1	16.6
	0707	10	31.9					
	0708	8	31.8		8/19/95	0953	14	32.5
	0709	6	31.4			0954	12	32.2
	0710	4	30.7			0955	10	31.7
	0711	2	21.8			0956	8	31.7
8/19/95	0711	1	17.1			0957	6	31.2
						0958	4	27.2
8/19/95	0800	14	32.7			0959	2	18.4
	0801	12	32.5		8/19/95	0959	1	15.8
	0802	10	32.1					
	0803	8	31.8		8/19/95	1141	16	32.5
	0804	6	31.3			1142	14	32.5
	0805	4	31.0			1143	12	32.1
	0806	2	18.2			1144	10	31.9
8/19/95	0806	1	16.3			1145	8	31.4
						1146	6	30.0
8/19/95	0912	14	32.1			1147	4	24.4
	0913	12	31.6			1148	2	19.8
	0914	10	31.6		8/19/95	1148	1	17.7
8/19/95	0915	8	31.5					

Table 6 (concluded)
Salinity Profile Data Collection Range R5.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/19/95	1255	14	32.2		8/19/95	1522	16	31.7
	1256	12	32.1			1523	14	31.5
	1257	10	32.0			1524	12	31.1
	1258	8	31.7			1525	10	30.9
	1259	6	29.9			1526	8	30.5
	1300	4	26.7			1527	6	28.6
	1301	2	20.4			1528	4	25.1
8/19/95	1302	1	17.3			1529	2	23.9
					8/19/95	1529	1	20.1
8/19/95	1417	18	31.9					
	1418	16	31.8		8/19/95	1636	18	31.4
	1419	14	31.6			1637	16	31.5
	1420	12	31.6			1638	14	31.5
	1421	10	31.6			1639	12	31.3
	1422	8	31.0			1640	10	31.0
	1423	6	27.6			1641	8	29.7
	1424	4	25.0			1642	6	29.2
	1425	2	21.6			1643	4	26.6
8/19/95	1425	1	18.5 (* 17.88)			1644	2	24.2
					8/19/95	1644	1	21.6

* = Water sample laboratory analysis

Table 7
Salinity Profile Data Collection Range R6.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/17/95	0654	5	25.5		08/17/95	1311	6	31.2
	0655	4	25.5			1312	4	31.2
	0656	2	25.5			1313	2	29.3
08/17/95	0656	1	25.6		08/17/95	1313	1	18.7
8/17/95	0752	4	25.7		08/17/95	1407	5	31.5
	0753	2	25.7			1408	4	31.5
08/17/95	0754	1	25.7 (* 25.98)			1409	2	27.2
					08/17/95	1409	1	22.4 (*22.33)
8/17/95	0852	5	25.6		08/17/95	1600	5	31.3
	0853	4	25.6			1601	4	31.2
	0854	2	25.6			1602	2	27.5
08/17/95	0854	1	25.7		08/17/95	1602	1	20.4
8/17/95	1009	5	25.6		08/17/95	1656	5	31.4
						1657	4	31.2
						1658	2	25.5
					08/17/95	1658	1	21.1
8/17/95	1118	5	30.5		08/18/95	0837	5	24.9
	1119	4	29.4			0838	4	24.8
	1120	2	25.8			0839	2	24.6
08/17/95	1120	1	23.0		08/18/95	0839	1	24.6 (*25.81)

* = Water sample laboratory analysis

Table 7 (continued)
Salinity Profile Data Collection Range R6.0

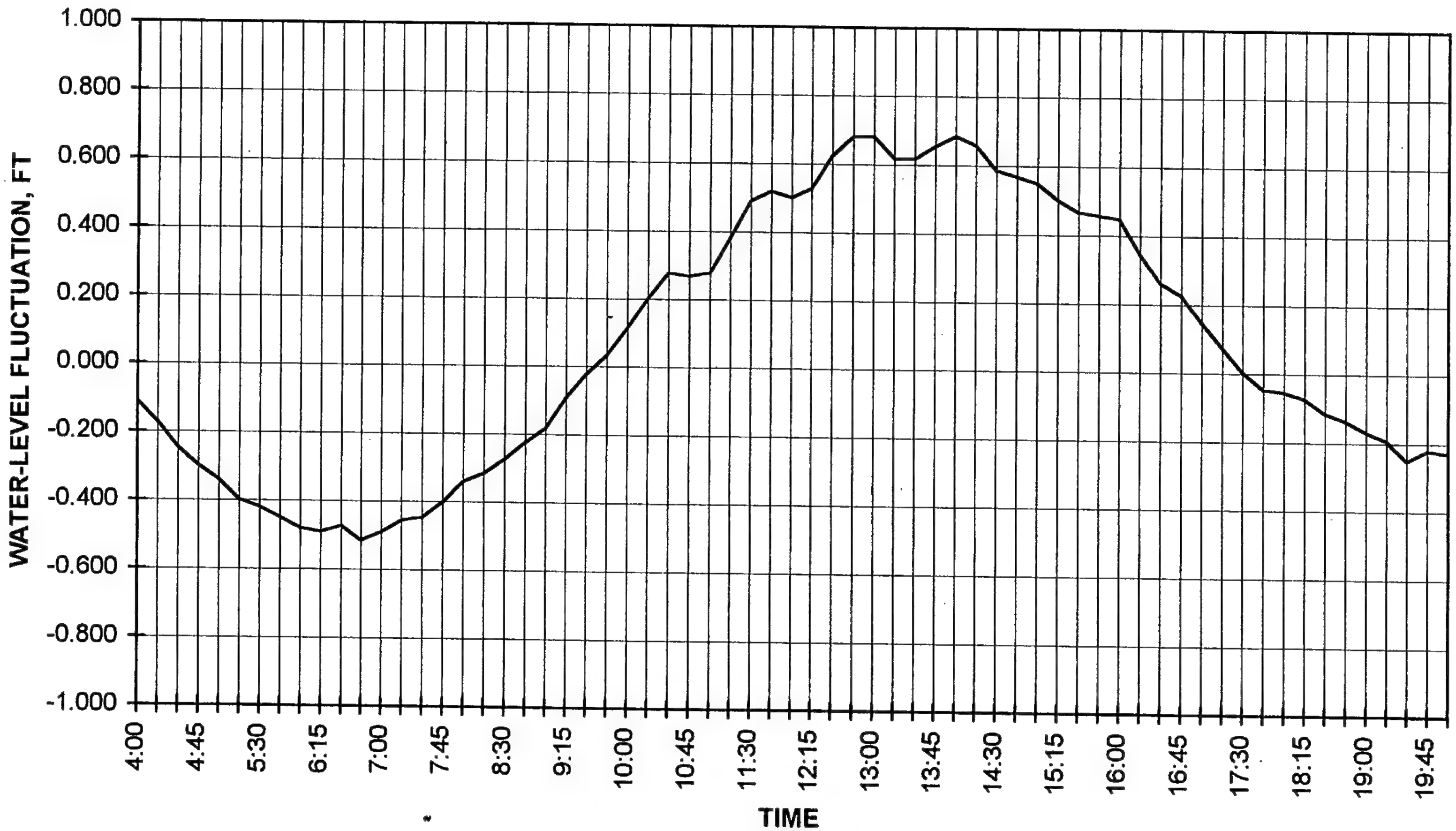
Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/18/95	0933	4	24.9		8/18/95	1607	5	30.4
	0934	2	24.8			1608	4	27.4
8/18/95	0934	1	24.8			1609	2	25.7
					8/18/95	1609	1	11.6
8/18/95	1055	4	24.9					
	1056	2	24.5					
8/18/95	1056	1	20.3		8/18/95	1701	5	29.3
						1702	4	26.2
8/18/95	1206	5	28.0			1703	2	24.9
	1207	4	26.0		8/18/95	1703	1	14.2
	1208	2	24.5					
8/18/95	1208	1	14.3		8/19/95	0619	4	22.2
						0620	2	22.0
8/18/95	1313	5	30.4		08/19/95	0620	1	7.3 (* 9.23)
	1314	4	26.1					
	1315	2	22.2		8/19/95	0717	4	24.1
8/18/95	1315	1	13.8			0718	2	23.6
					8/19/95	0718	1	7.7
8/18/95	1458	5	30.4					
	1459	4	26.7		8/19/95	0823	4	24.6
	1500	2	23.6			0824	2	24.5
8/18/95	1500	1	12.2		8/19/95	0824	1	22.8
					8/19/95	0927	4	24.1
						0928	2	24.0
					8/19/95	0928	1	23.6

* = Water sample laboratory analysis

Table 7 (concluded)
Salinity Profile Data Collection Range R6.0

Date	Time EST	Depth, ft	Salinity, ppt		Date	Time EST	Depth, ft	Salinity, ppt
8/19/95	1026	4	24.4		8/19/95	1433	5	30.7
	1027	2	24.2			1434	4	28.4
8/19/95	1027	1	23.9			1435	2	26.2
					8/19/95	1435	1	11.3 (* 11.40)
8/19/95	1156	5	23.8		8/19/95	1536	5	30.9
	1157	4	23.7			1537	4	26.3
	1158	2	23.2			1538	2	17.6
8/19/95	1158	1	4.2		8/19/95	1538	1	11.2
8/19/95	1310	5	28.6		8/19/95	1651	5	31.5
	1311	4	26.5			1652	4	30.7
	1312	2	20.1			1653	2	23.0
8/19/95	1312	1	8.1		8/19/95	1653	1	15.1

* = Water sample laboratory analysis



WATER-LEVEL FLUCTUATIONS
STATION S1.0
AUGUST 17, 1995

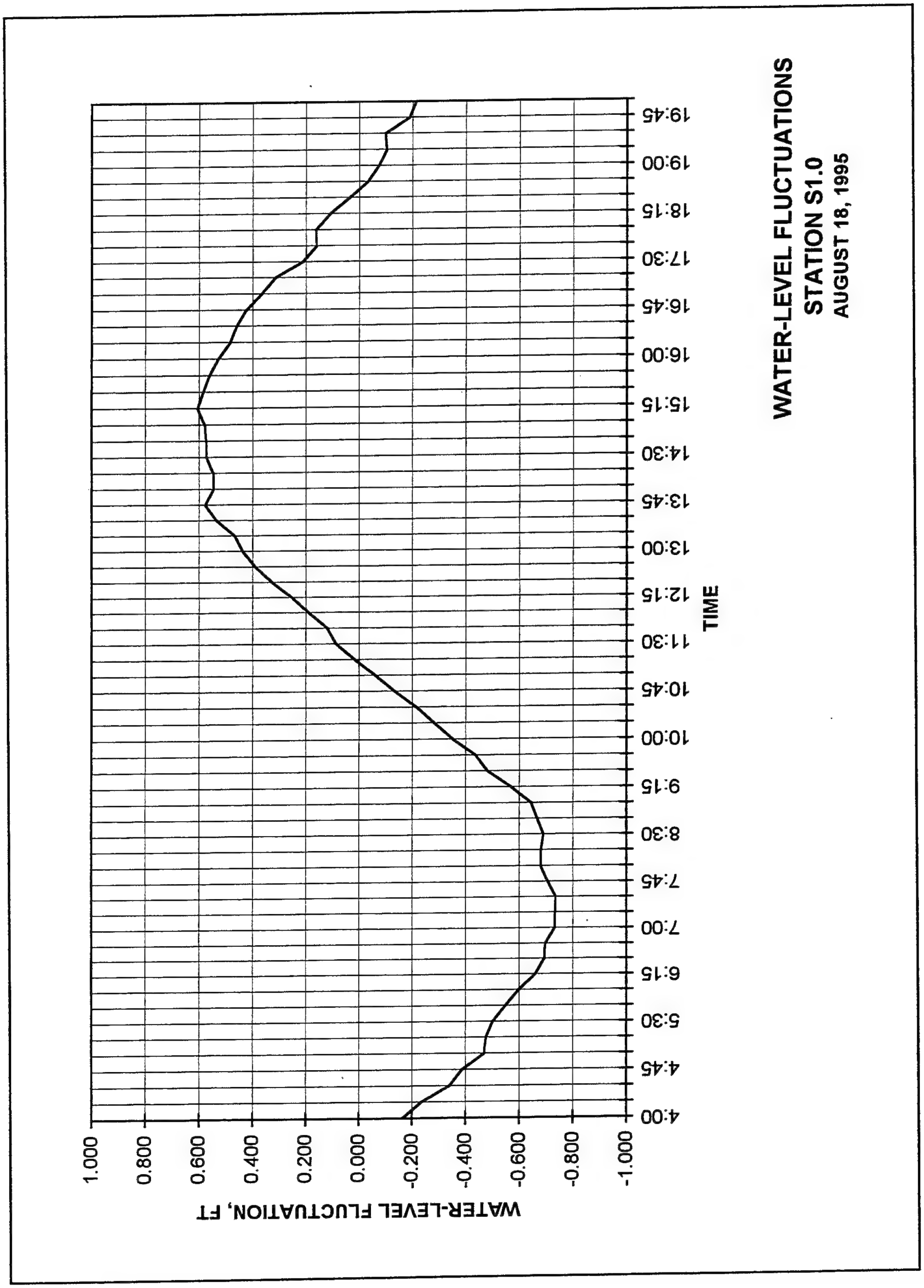
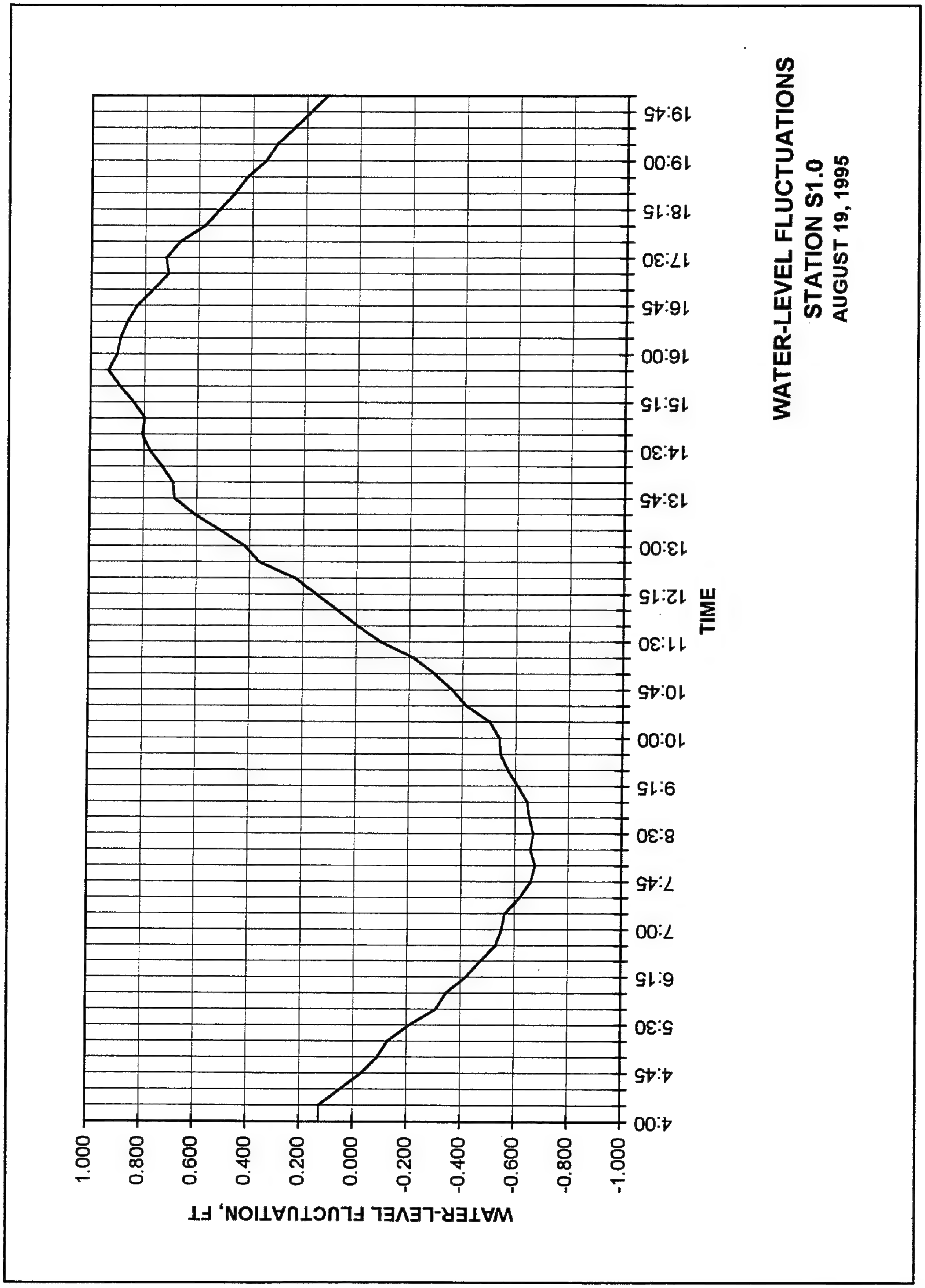

WATER-LEVEL FLUCTUATIONS
STATION S1.0
AUGUST 18, 1995
WATER-LEVEL FLUCTUATION, FT
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
TIME
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
11:30
12:15
13:00
13:45
14:30
15:15
16:00
16:45
17:30
18:15
19:00
19:45

Plate 2



WATER-LEVEL FLUCTUATIONS
STATION S1.0
AUGUST 19, 1995
WATER-LEVEL FLUCTUATION, FT
TIME
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
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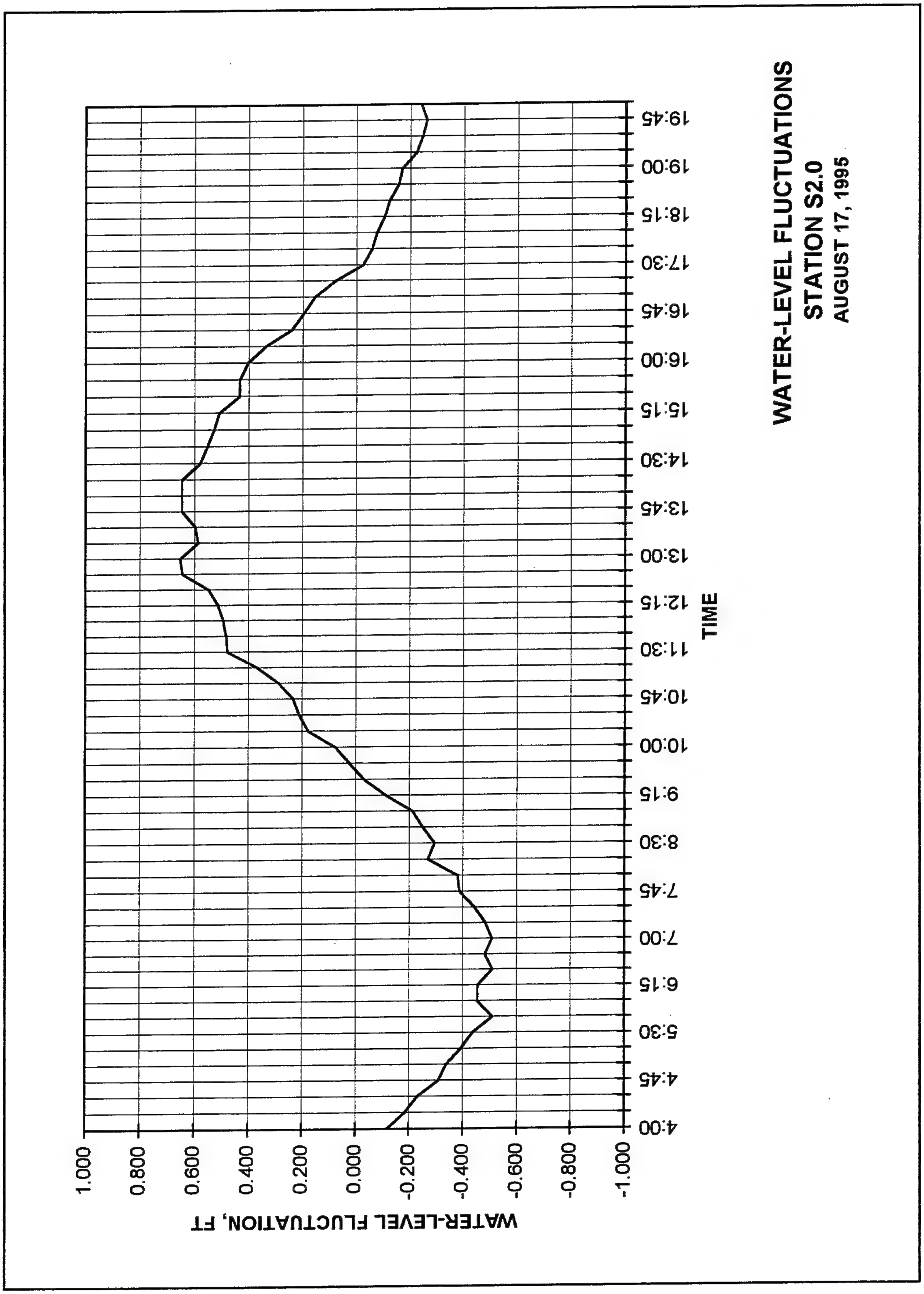
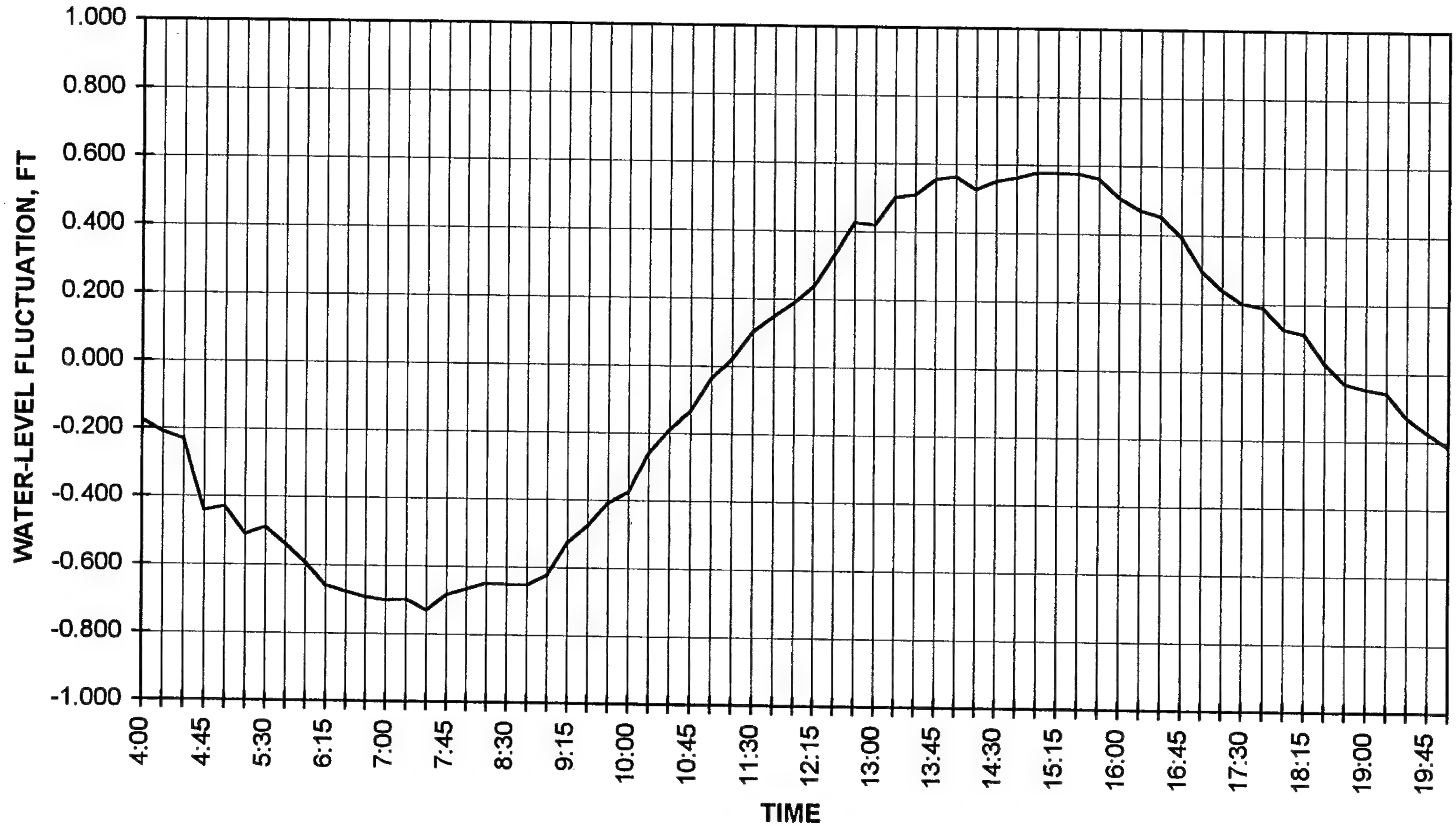
18:15
19:00
19:45



WATER-LEVEL FLUCTUATIONS
STATION S2.0
AUGUST 17, 1995
TIME
WATER-LEVEL FLUCTUATION, FT
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
11:30
12:15
13:00
13:45
14:30
15:15
16:00
16:45
17:30
18:15
19:00
19:45
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000

Plate 4



WATER-LEVEL FLUCTUATIONS
STATION S2.0
AUGUST 18, 1995

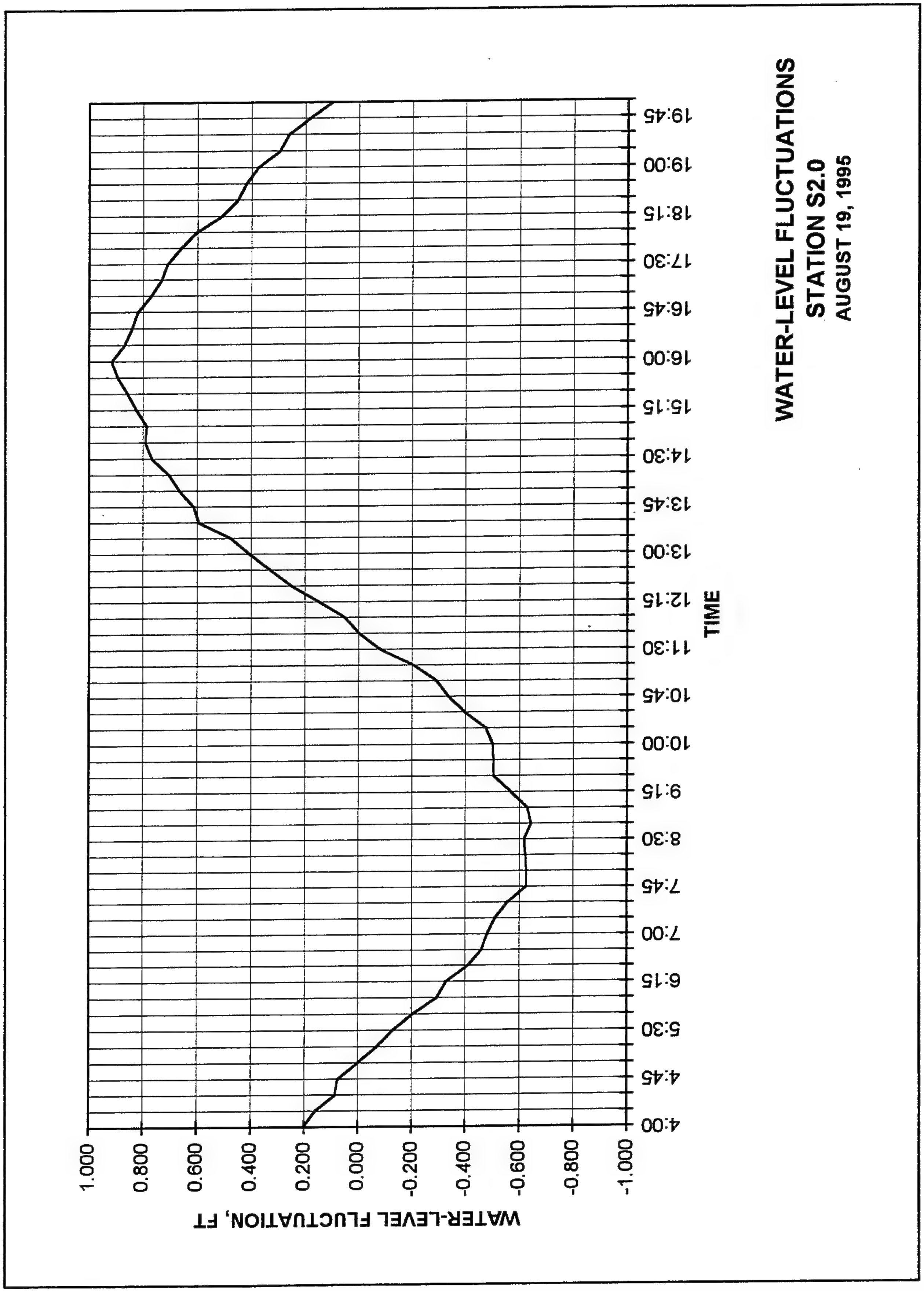
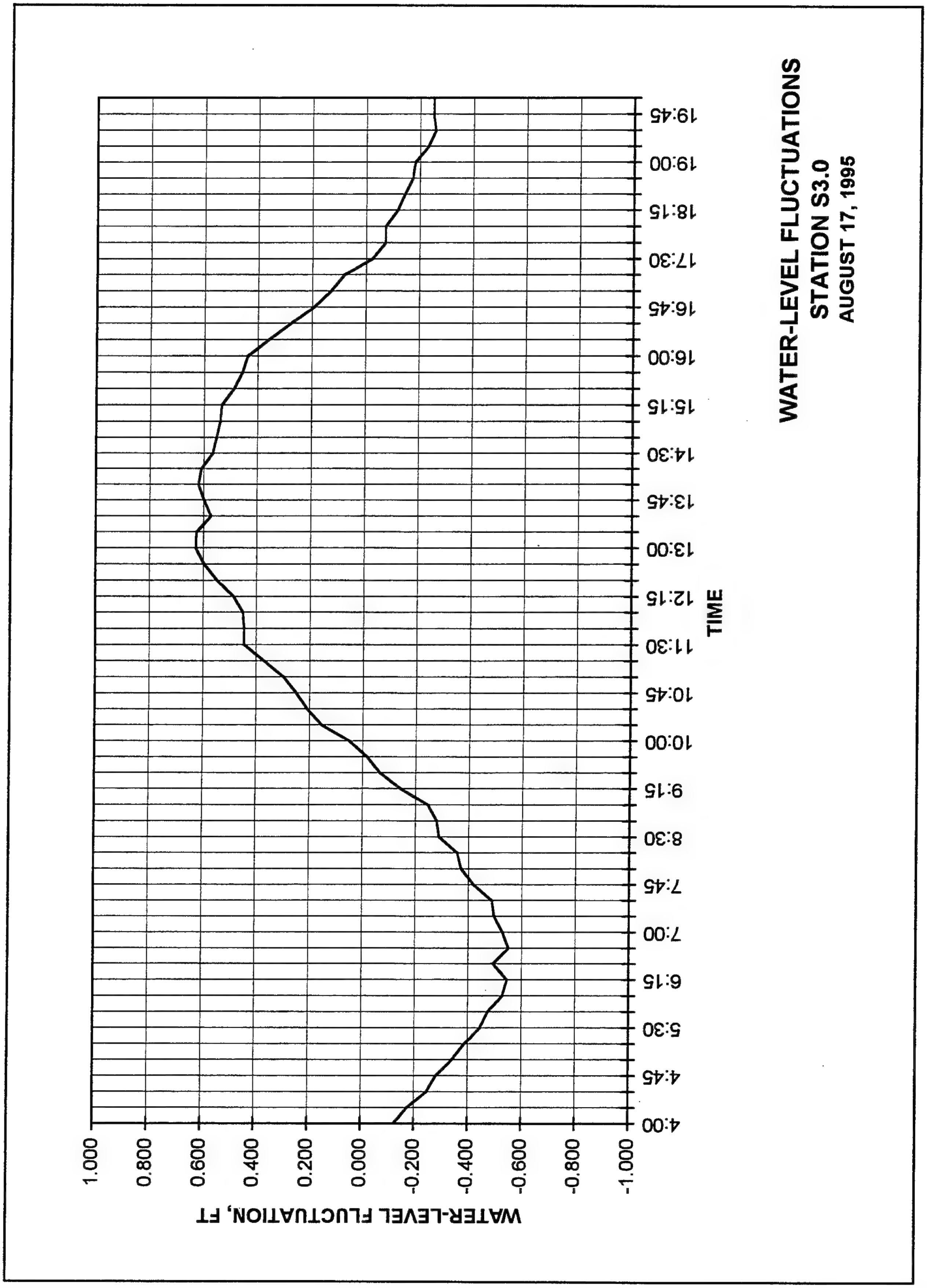

WATER-LEVEL FLUCTUATIONS
STATION S2.0
AUGUST 19, 1995
WATER-LEVEL FLUCTUATION, FT
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
TIME
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
11:30
12:15
13:00
13:45
14:30
15:15
16:00
16:45
17:30
18:15
19:00
19:45

Plate 6



WATER-LEVEL FLUCTUATIONS
STATION S3.0
AUGUST 17, 1995
WATER-LEVEL FLUCTUATION, FT
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
TIME
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
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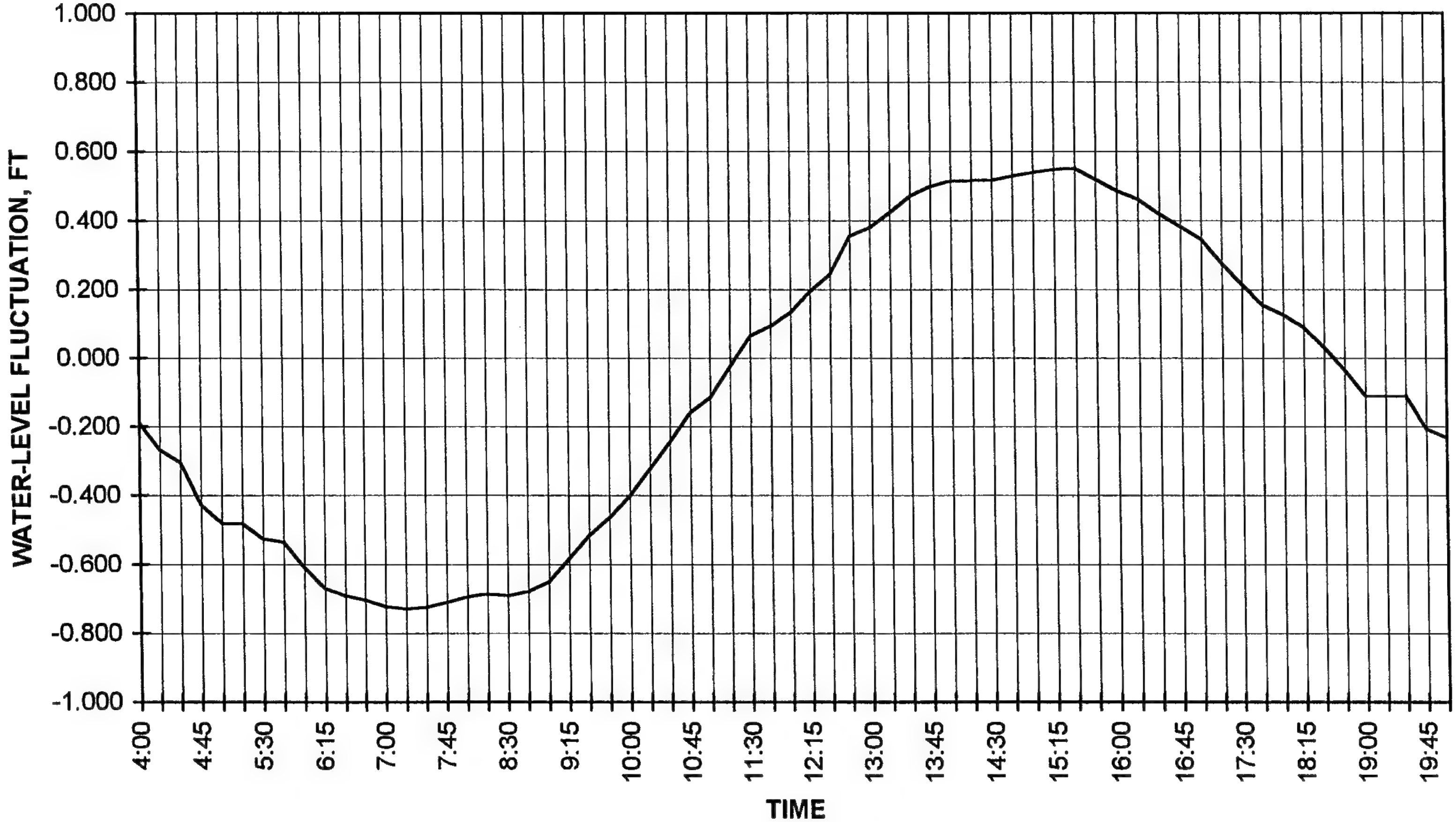
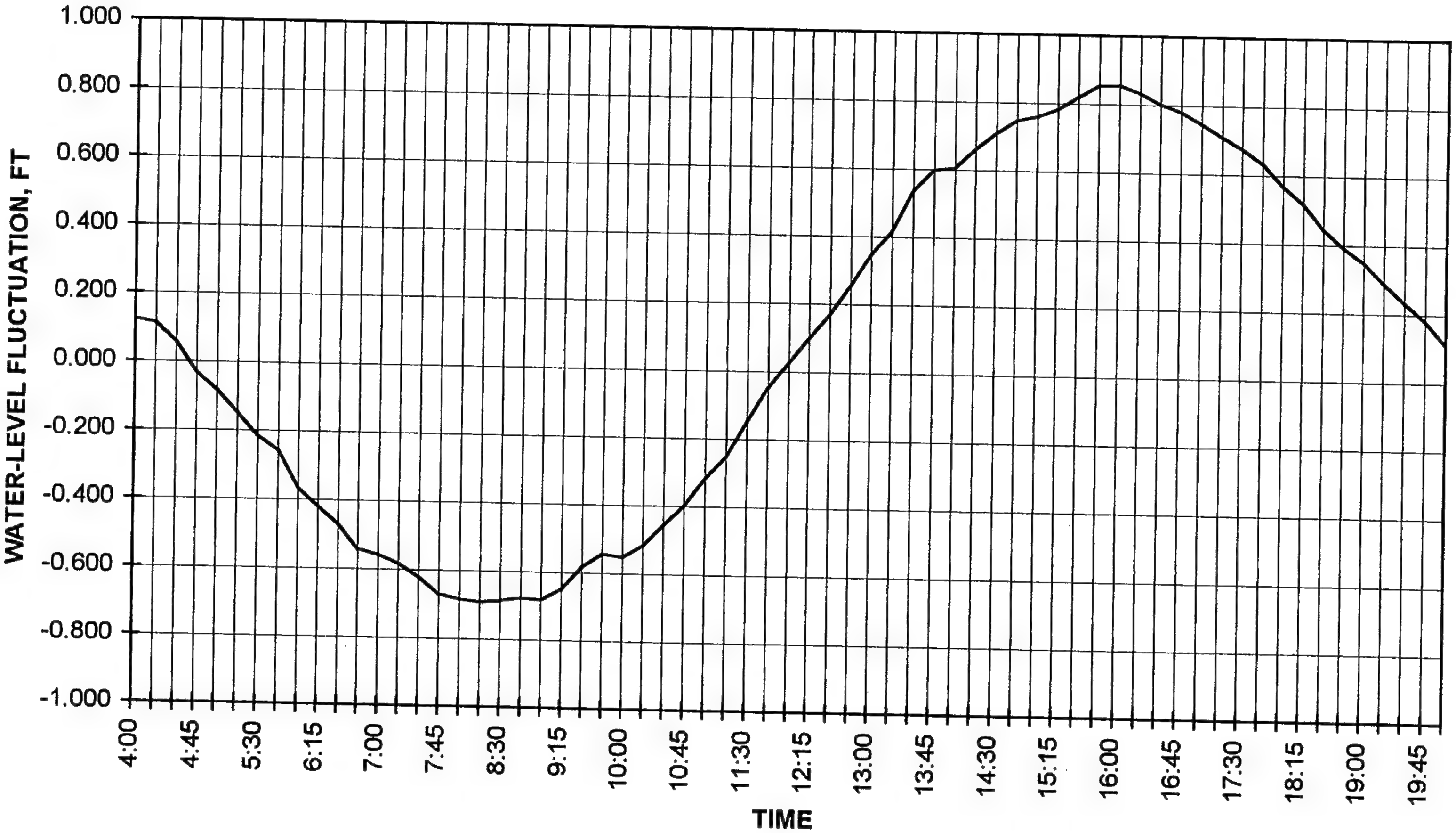
18:15
19:00
19:45



WATER-LEVEL FLUCTUATIONS
STATION S3.0
AUGUST 18, 1995



WATER-LEVEL FLUCTUATIONS
STATION S3.0
AUGUST 19, 1995

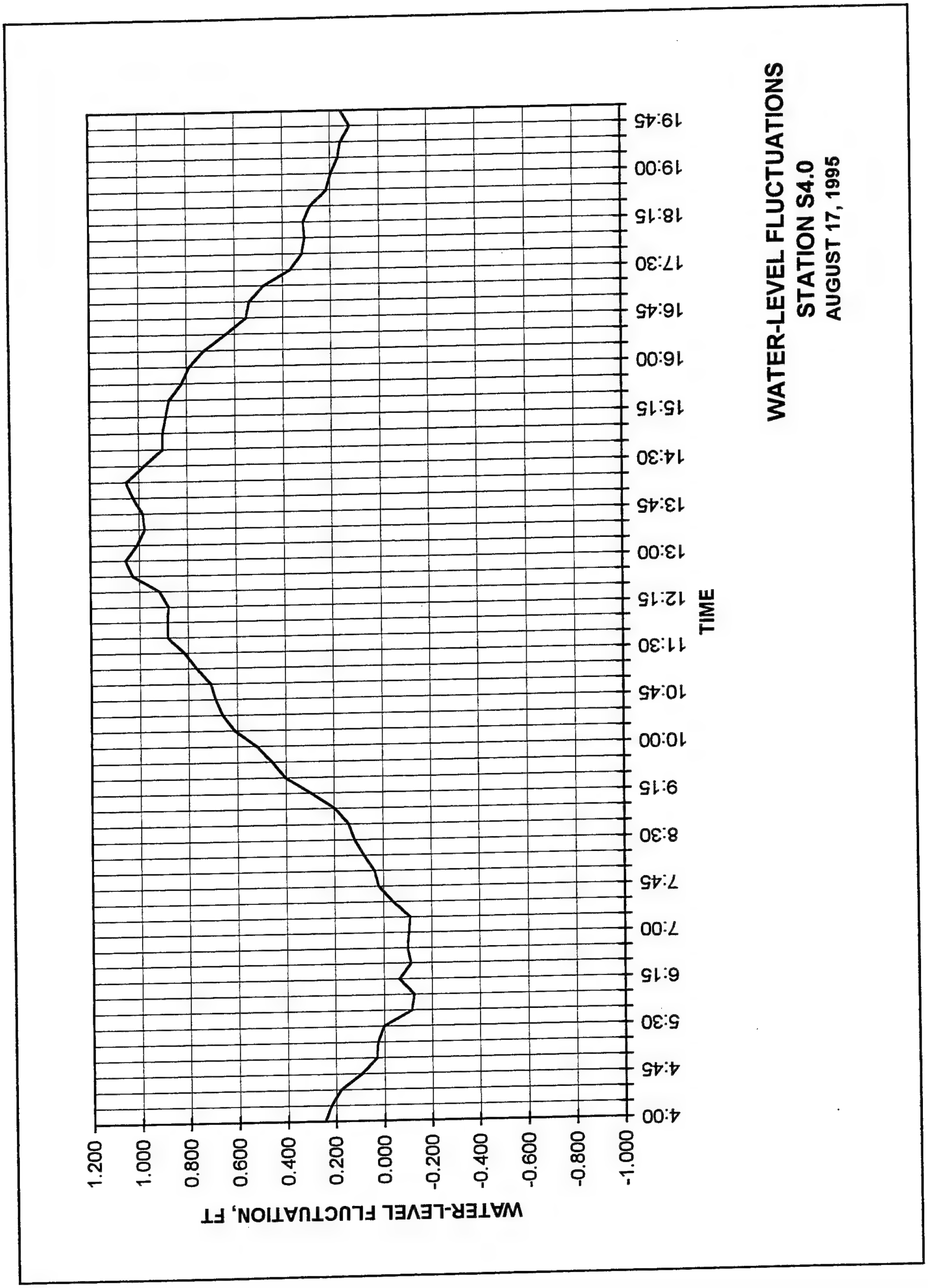
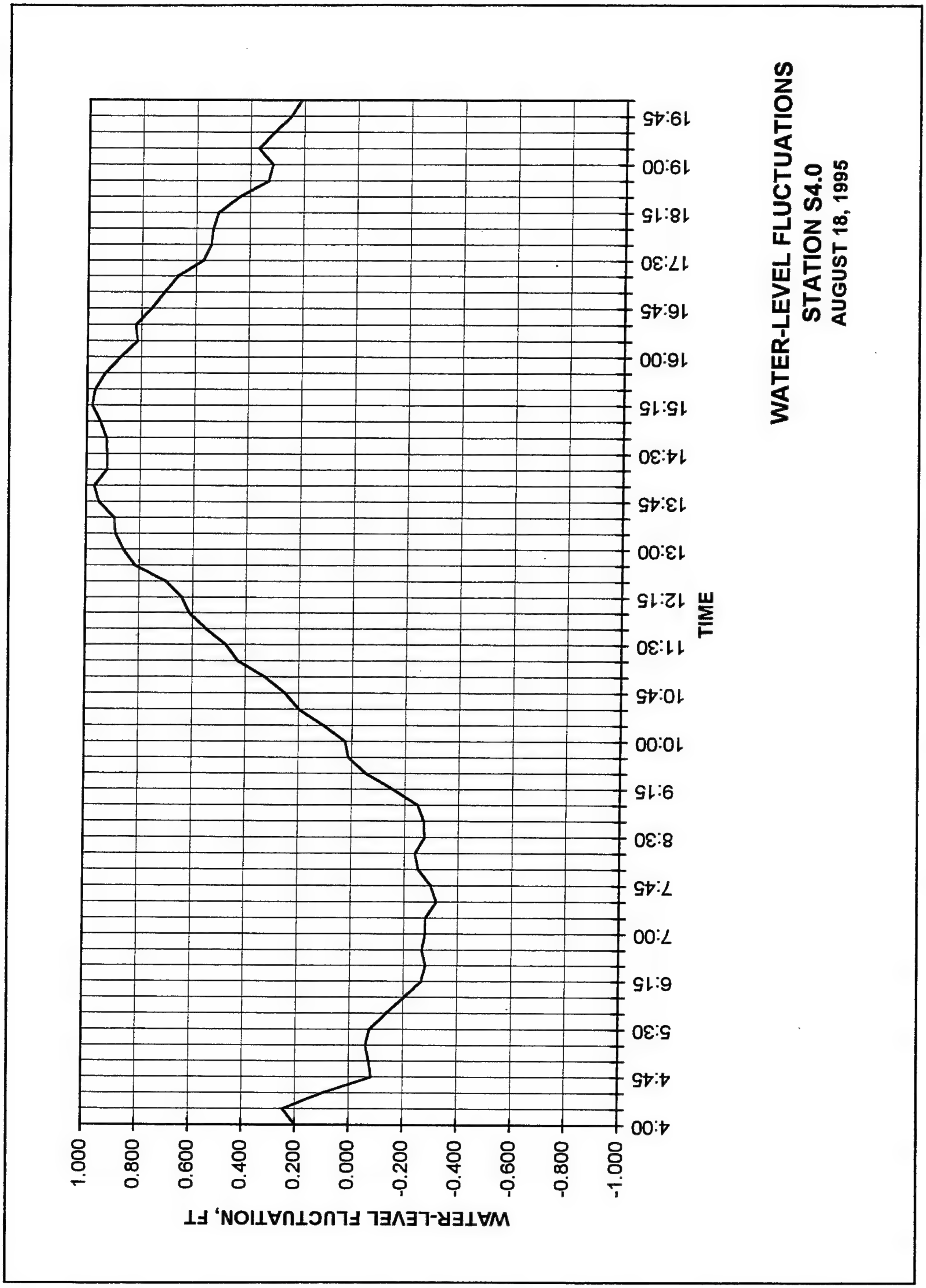

WATER-LEVEL FLUCTUATIONS
STATION S4.0
AUGUST 17, 1995
WATER-LEVEL FLUCTUATION, FT
TIME
1.200
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
11:30
12:15
13:00
13:45
14:30
15:15
16:00
16:45
17:30
18:15
19:00
19:45

Plate 10


WATER-LEVEL FLUCTUATIONS
STATION S4.0
AUGUST 18, 1995
WATER-LEVEL FLUCTUATION, FT
TIME
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
11:30
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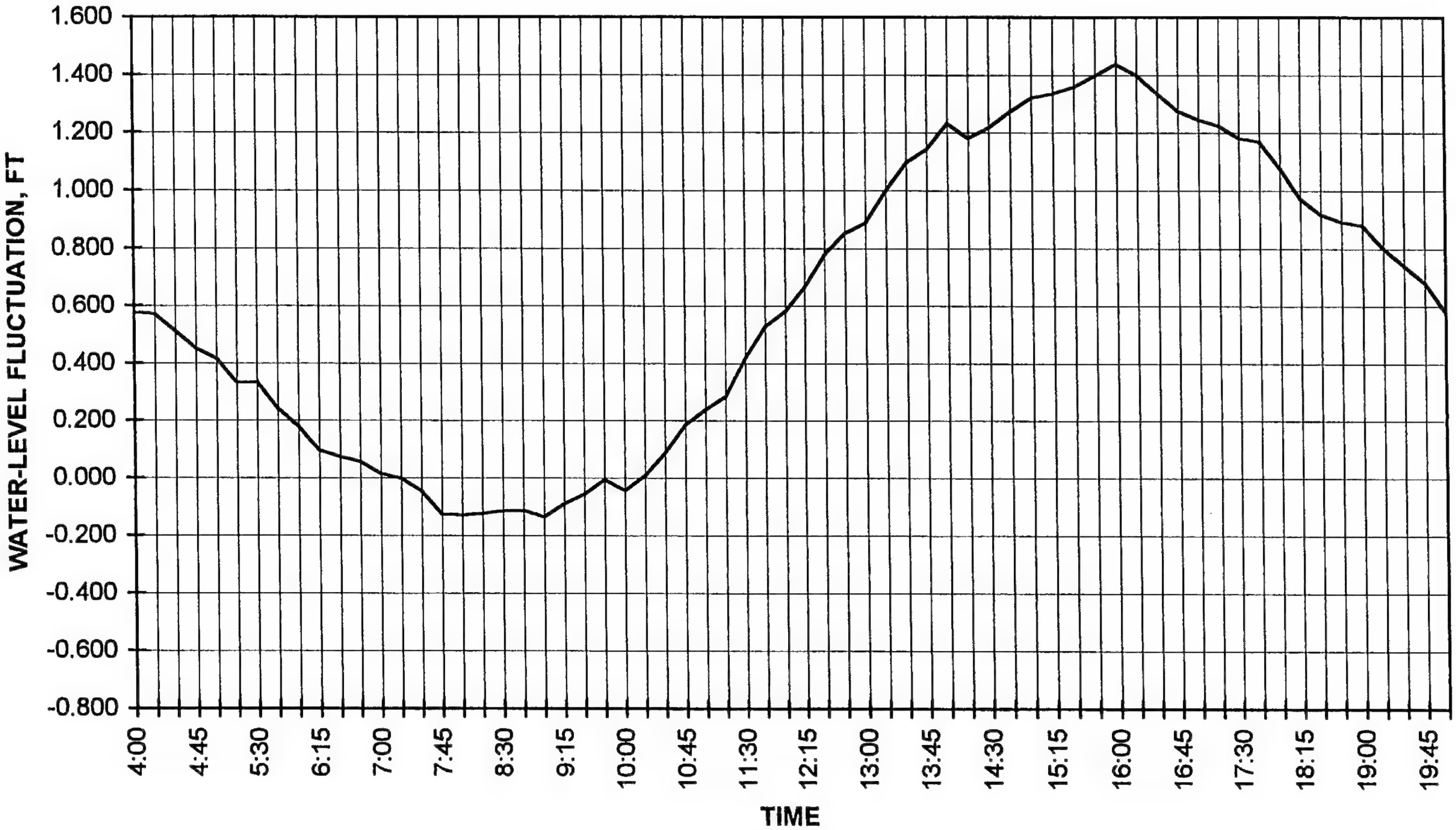
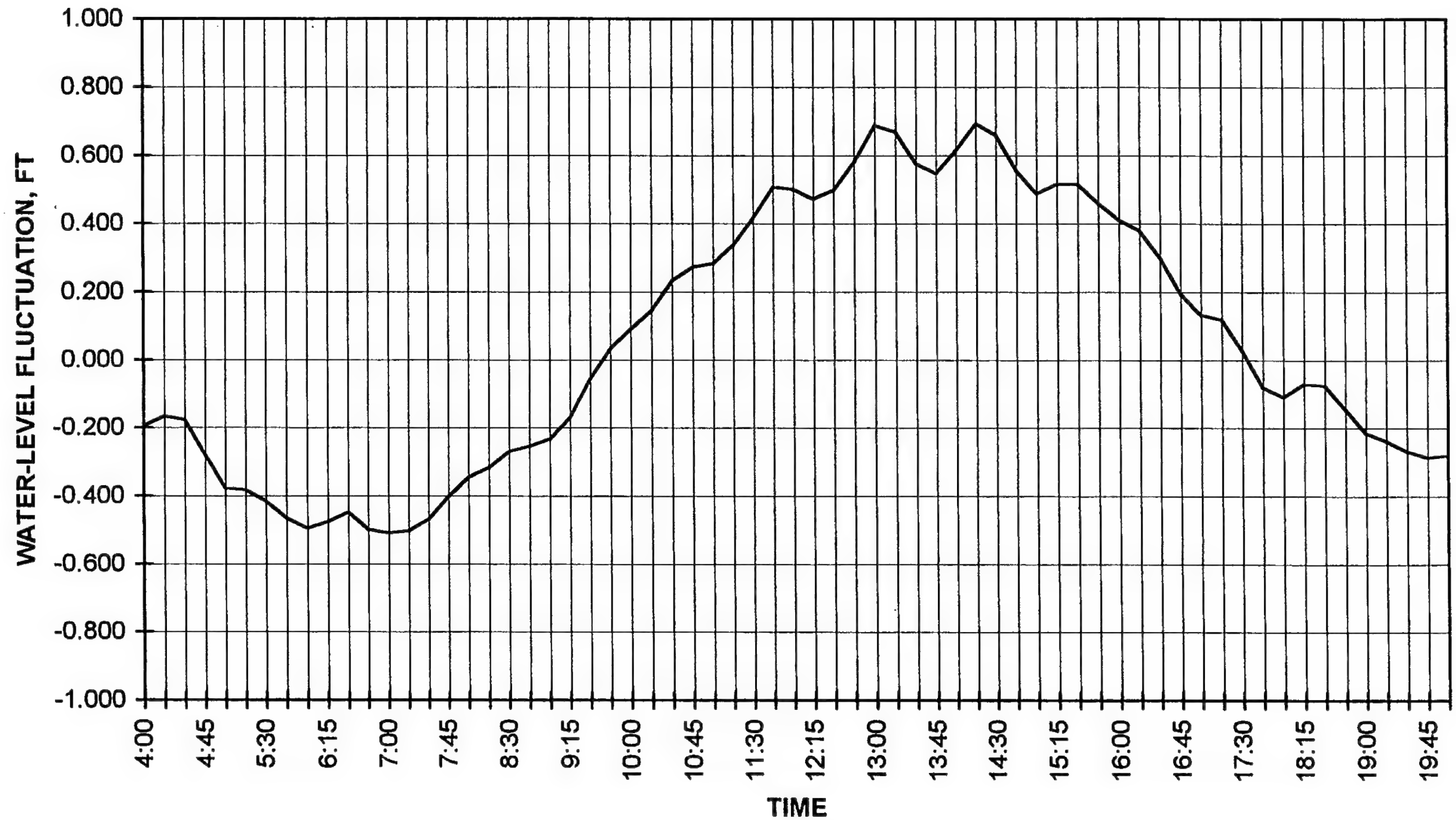
17:30
18:15
19:00
19:45



WATER-LEVEL FLUCTUATIONS
STATION S4.0
AUGUST 19, 1995



WATER-LEVEL FLUCTUATIONS
STATION S5.0
AUGUST 17, 1995

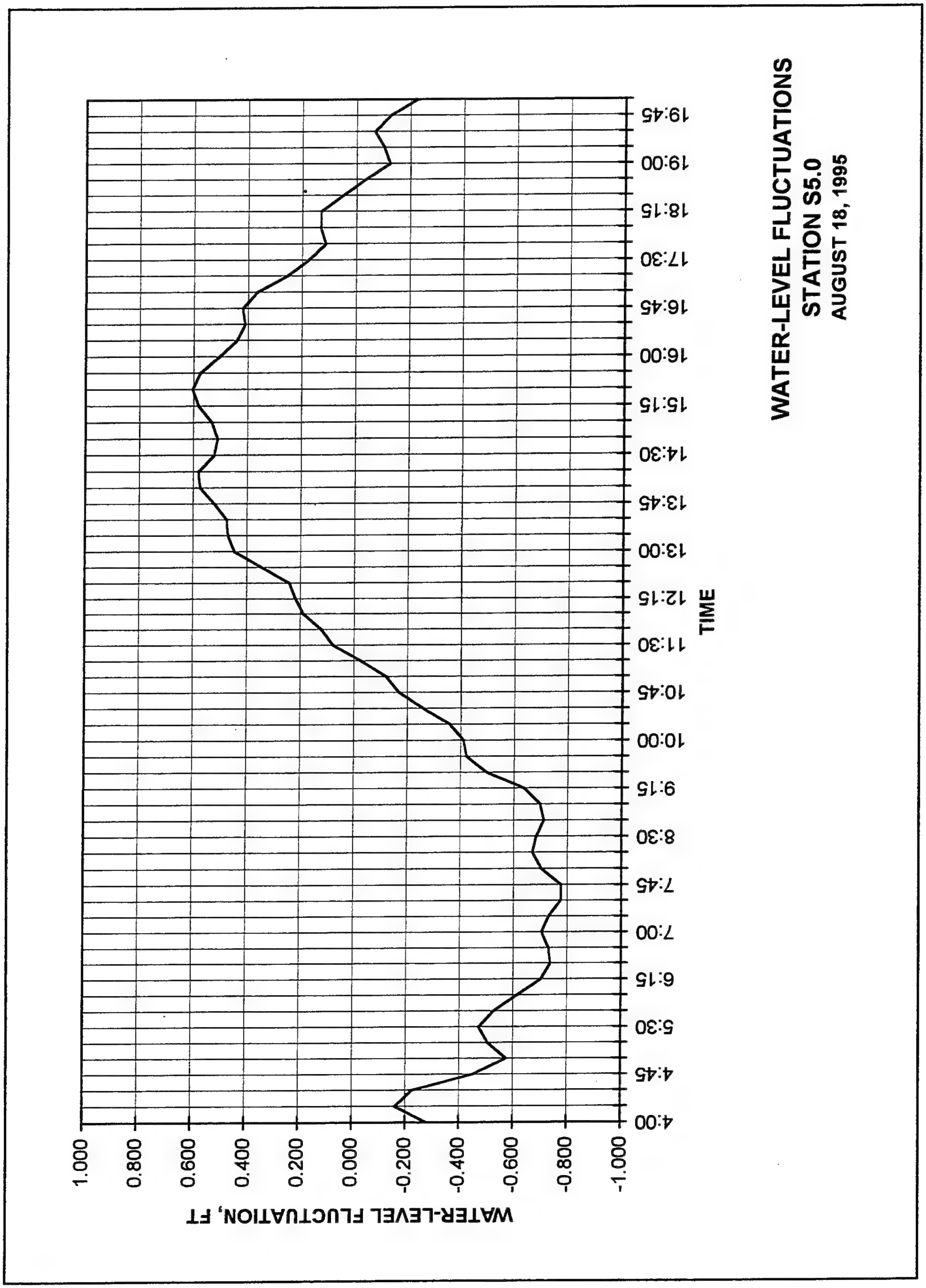
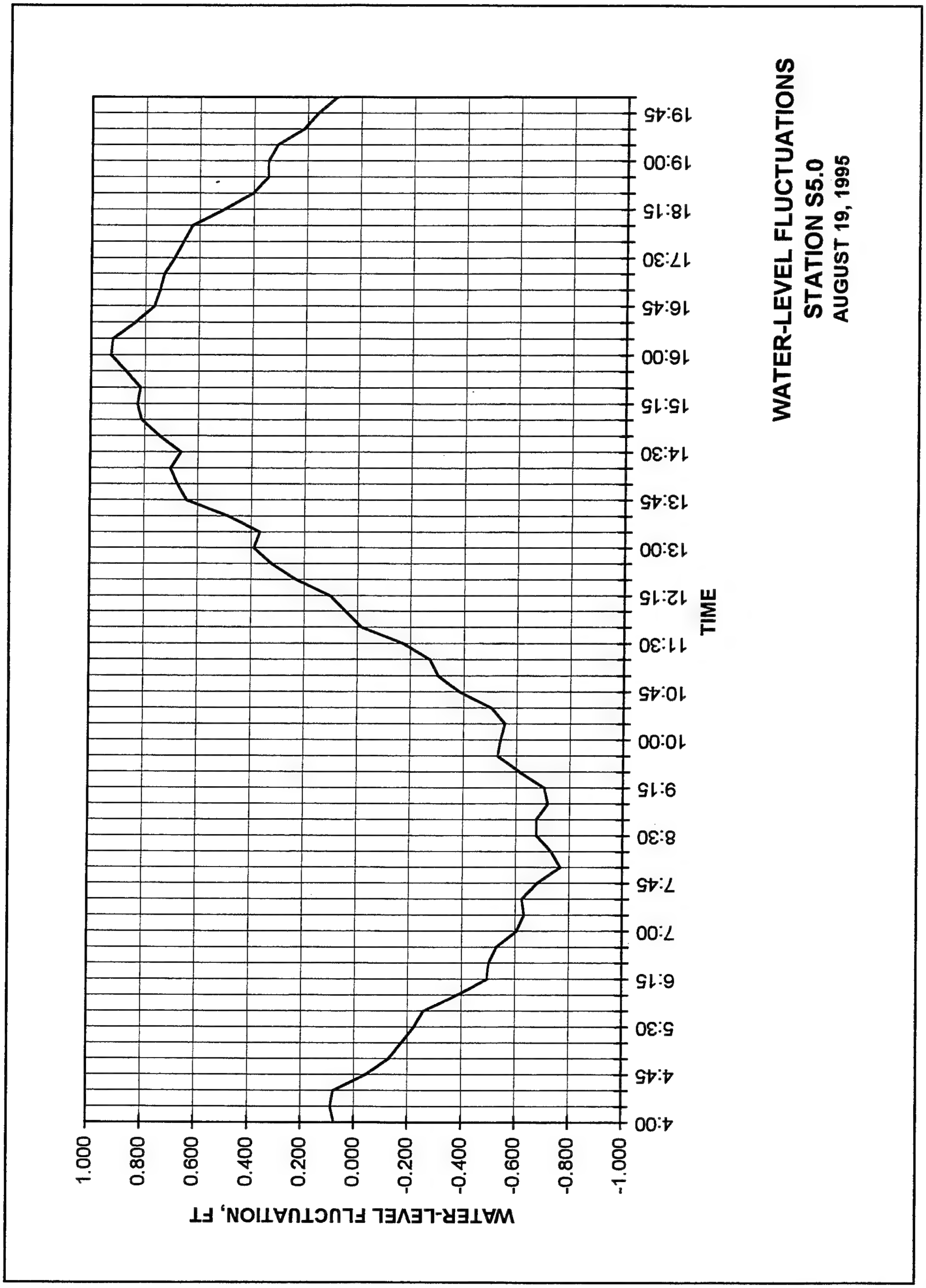

WATER-LEVEL FLUCTUATIONS
STATION S5.0
AUGUST 18, 1995
WATER-LEVEL FLUCTUATION, FT
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
TIME
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
11:30
12:15
13:00
13:45
14:30
15:15
16:00
16:45
17:30
18:15
19:00
19:45

Plate 14


WATER-LEVEL FLUCTUATIONS
STATION S5.0
AUGUST 19, 1995
WATER-LEVEL FLUCTUATION, FT
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
TIME
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
11:30
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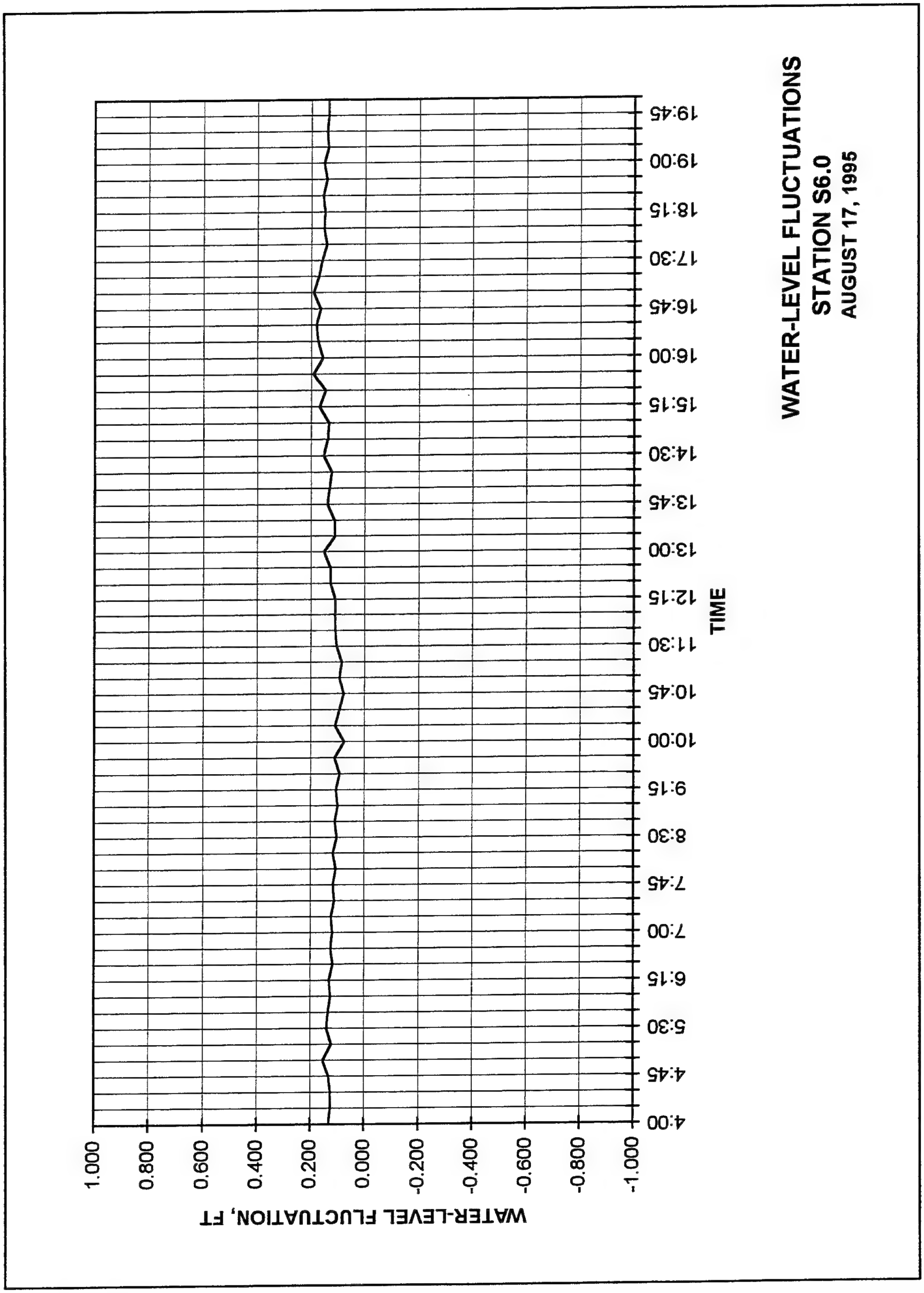
13:00
13:45
14:30
15:15
16:00
16:45
17:30
18:15
19:00
19:45


WATER-LEVEL FLUCTUATIONS
STATION S6.0
AUGUST 17, 1995
WATER-LEVEL FLUCTUATION, FT
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
TIME
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
11:30
12:15
13:00
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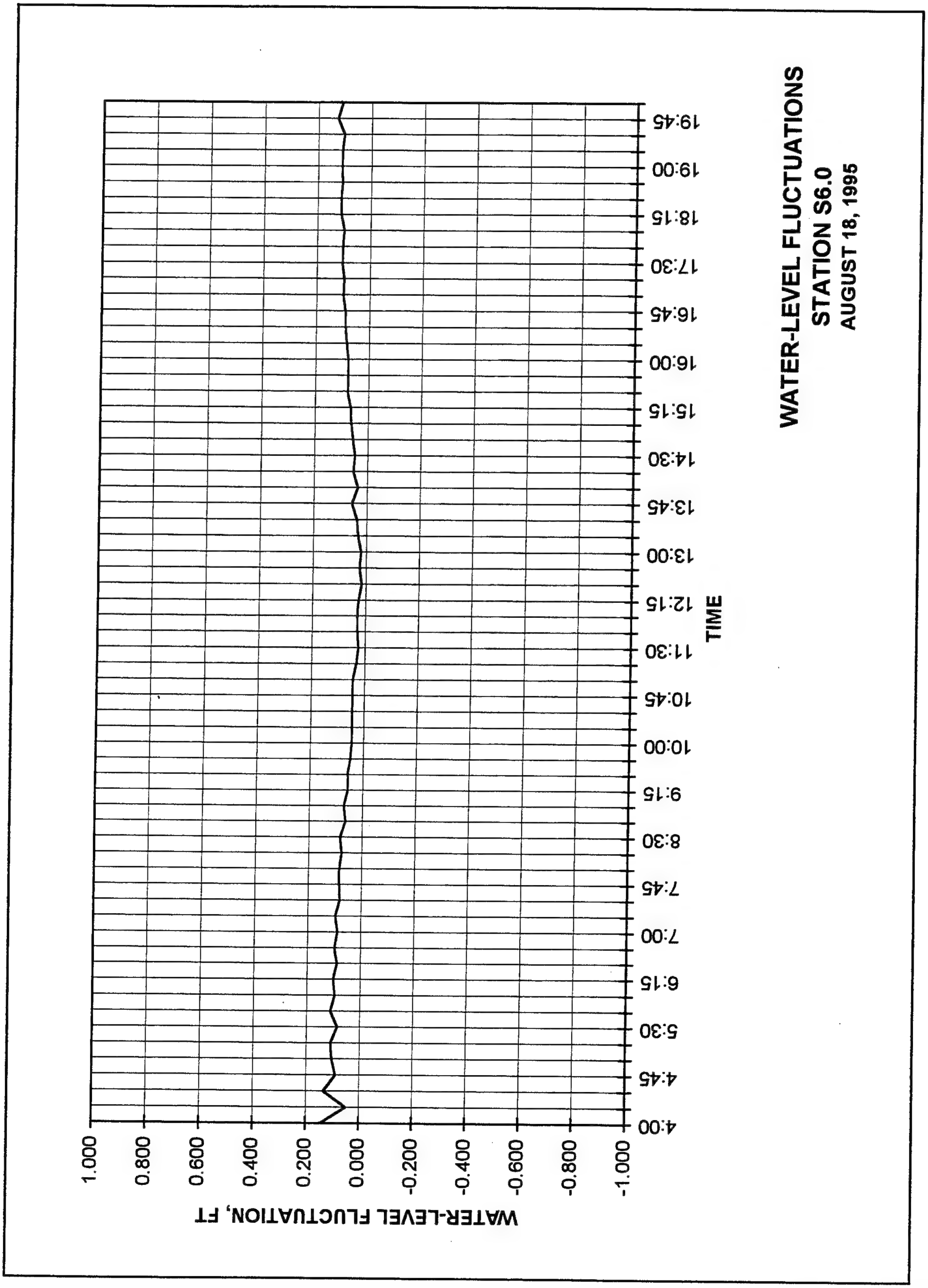
14:30
15:15
16:00
16:45
17:30
18:15
19:00
19:45

Plate 16


WATER-LEVEL FLUCTUATIONS
STATION S6.0
AUGUST 18, 1995
WATER-LEVEL FLUCTUATION, FT
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
TIME
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
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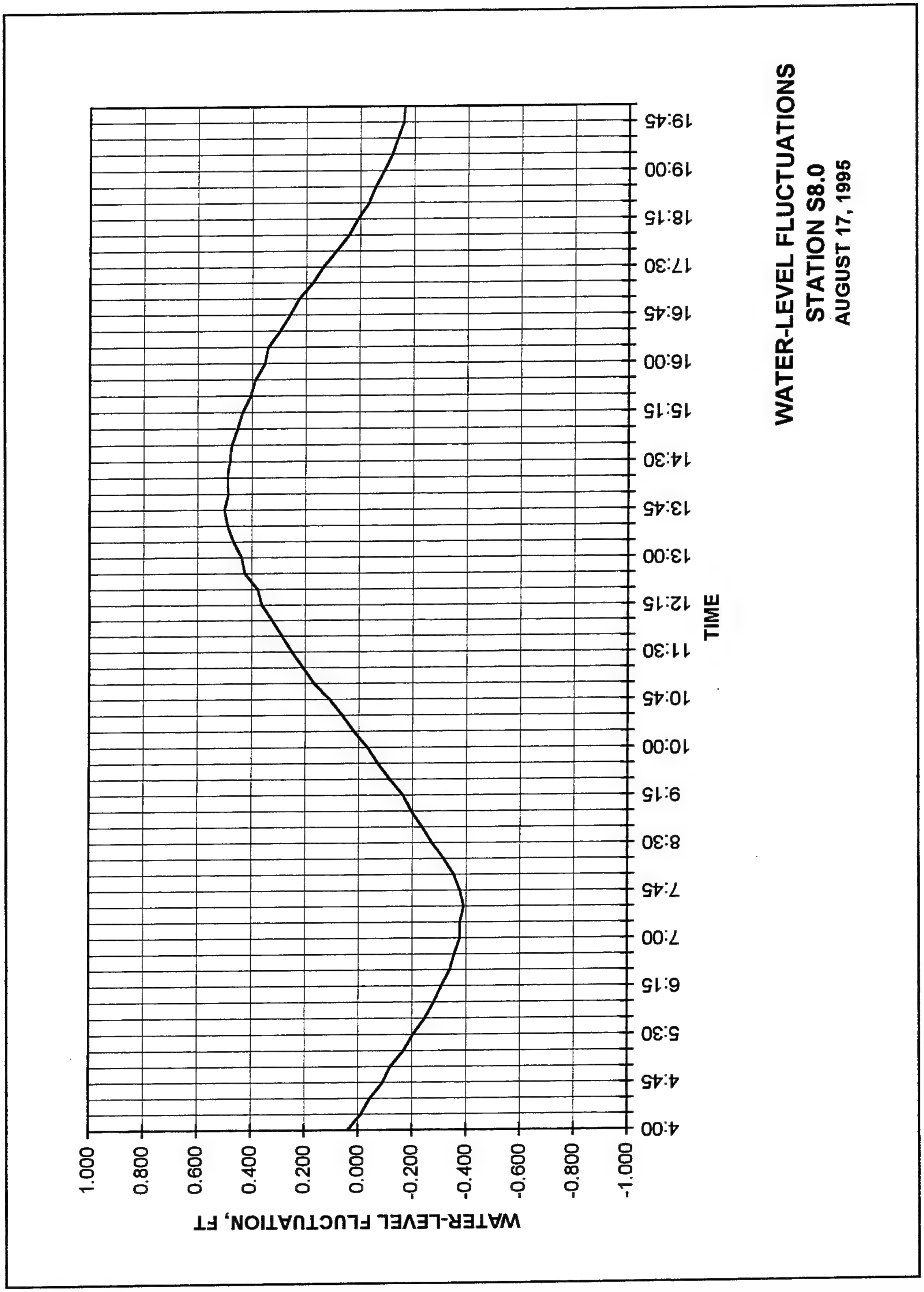
18:15
19:00
19:45


WATER-LEVEL FLUCTUATIONS
STATION S8.0
AUGUST 17, 1995
WATER-LEVEL FLUCTUATION, FT
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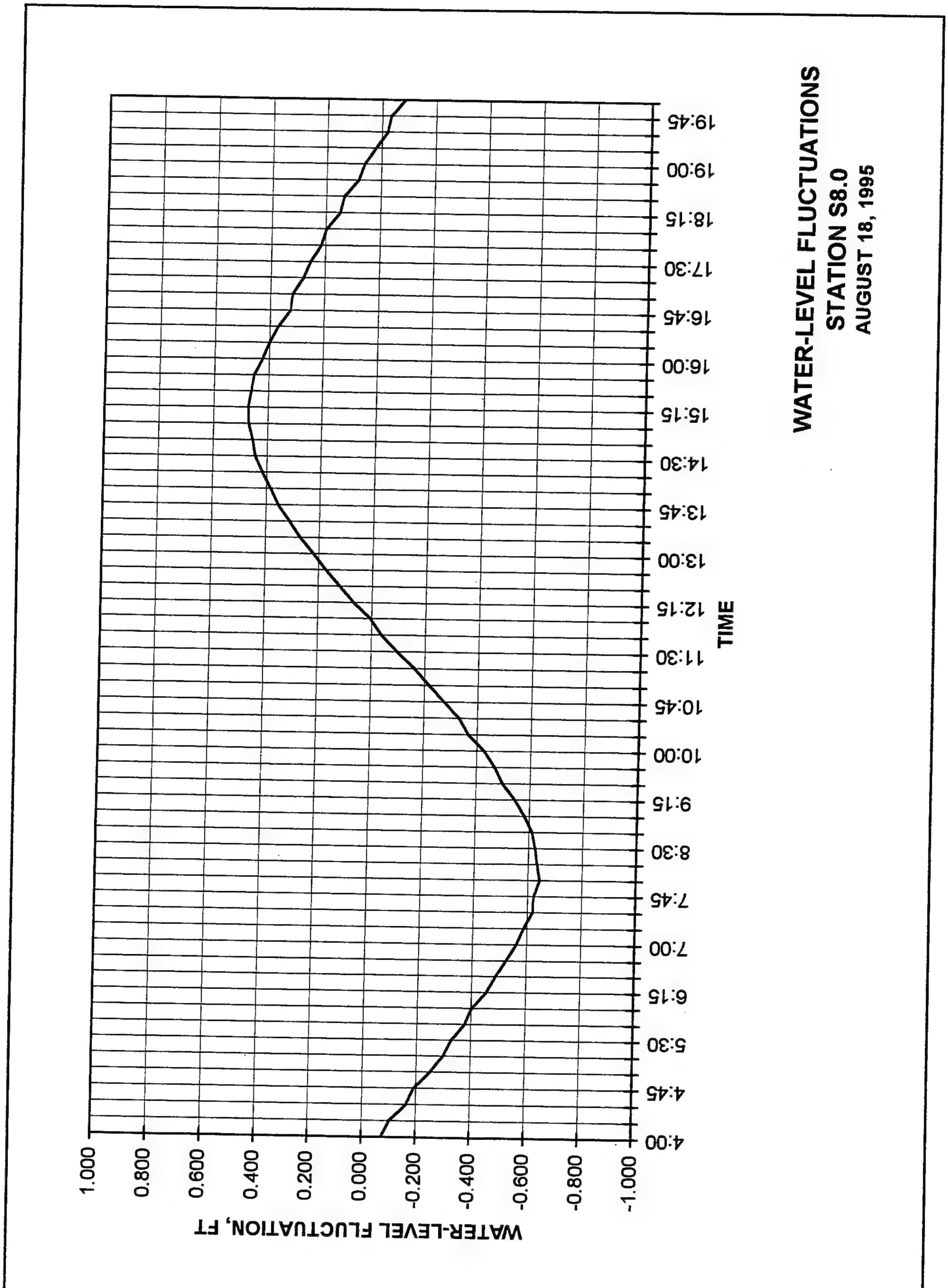
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
TIME
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
11:30
12:15
13:00
13:45
14:30
15:15
16:00
16:45
17:30
18:15
19:00
19:45

Plate 18


WATER-LEVEL FLUCTUATIONS
STATION S8.0
AUGUST 18, 1995
WATER-LEVEL FLUCTUATION, FT
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0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
TIME
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
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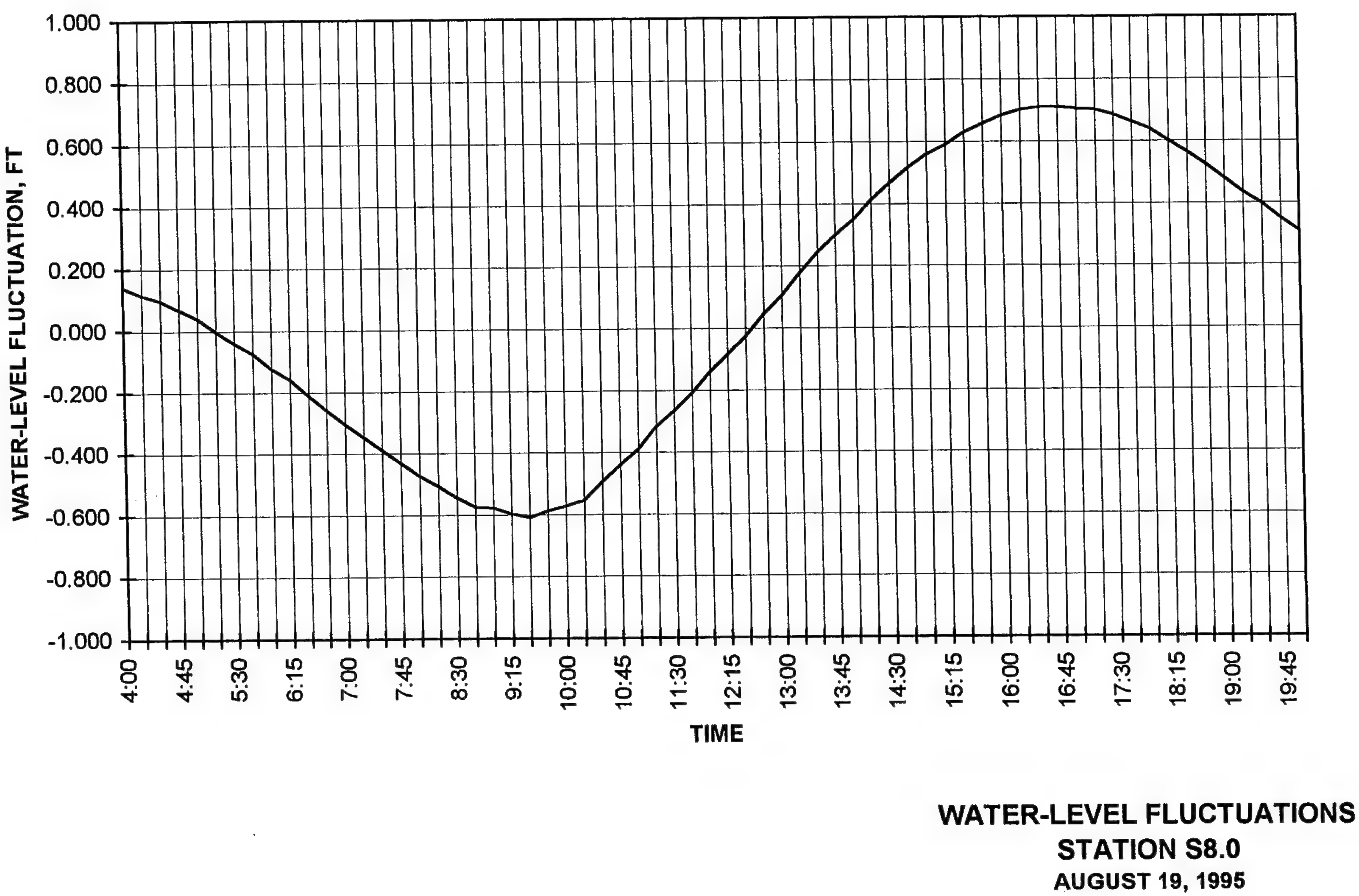
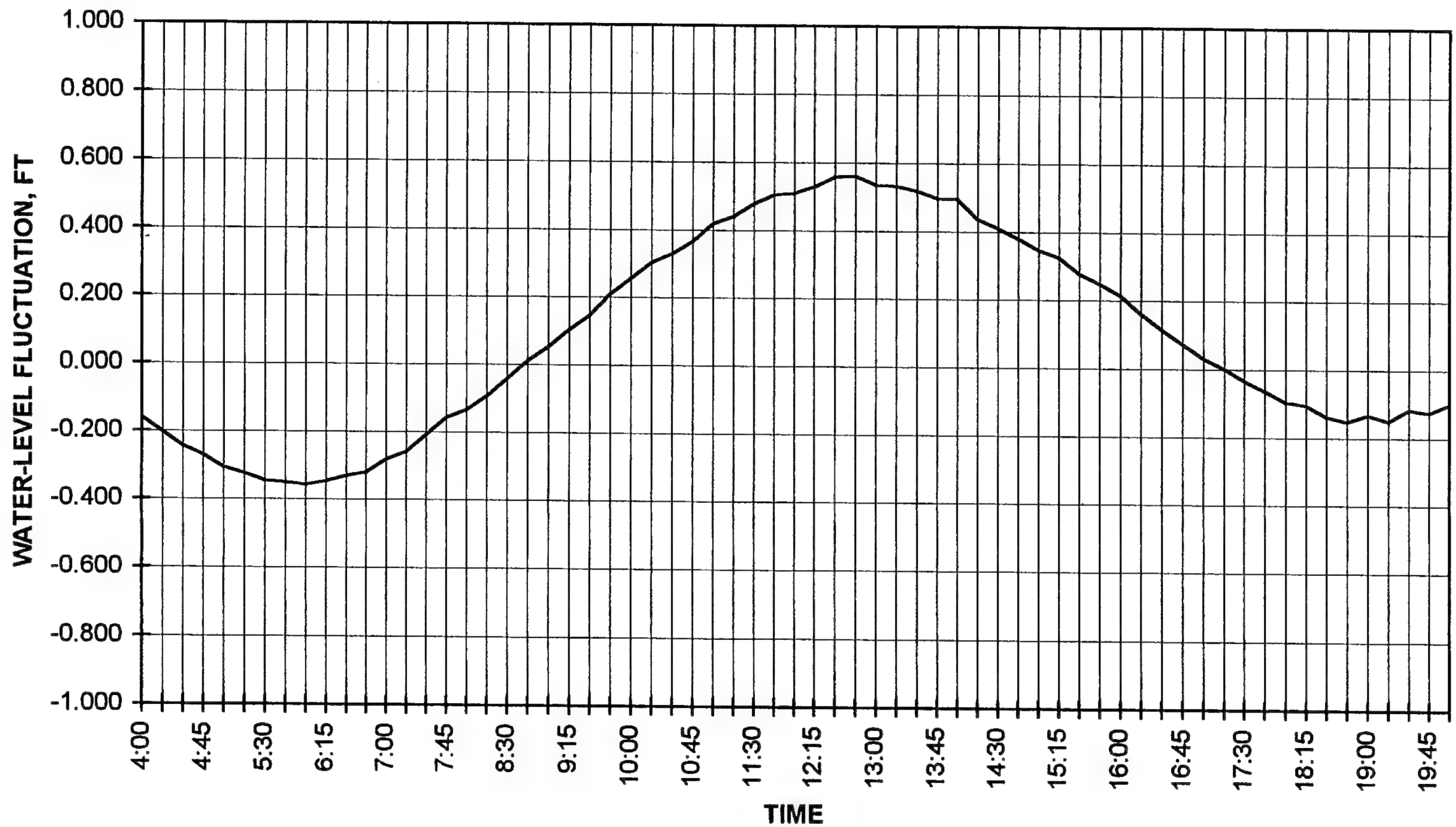
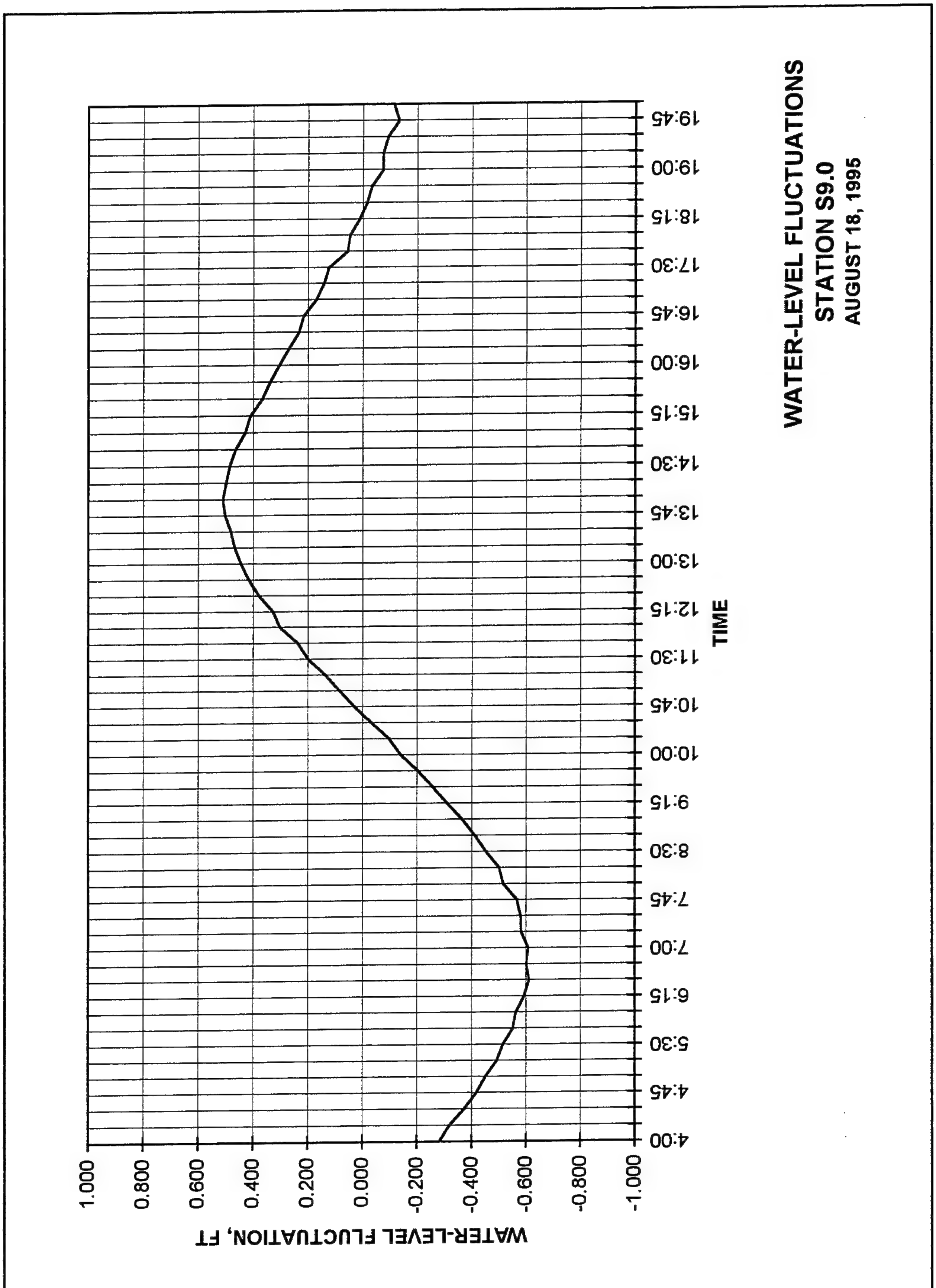
18:15
19:00
19:45


1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
WATER-LEVEL FLUCTUATION, FT
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
11:30
12:15
13:00
13:45
14:30
15:15
16:00
16:45
17:30
18:15
19:00
19:45
TIME
WATER-LEVEL FLUCTUATIONS
STATION S8.0
AUGUST 19, 1995



WATER-LEVEL FLUCTUATIONS
STATION S9.0
AUGUST 17, 1995


WATER-LEVEL FLUCTUATIONS
STATION S9.0
AUGUST 18, 1995
WATER-LEVEL FLUCTUATION, FT
TIME
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
11:30
12:15
13:00
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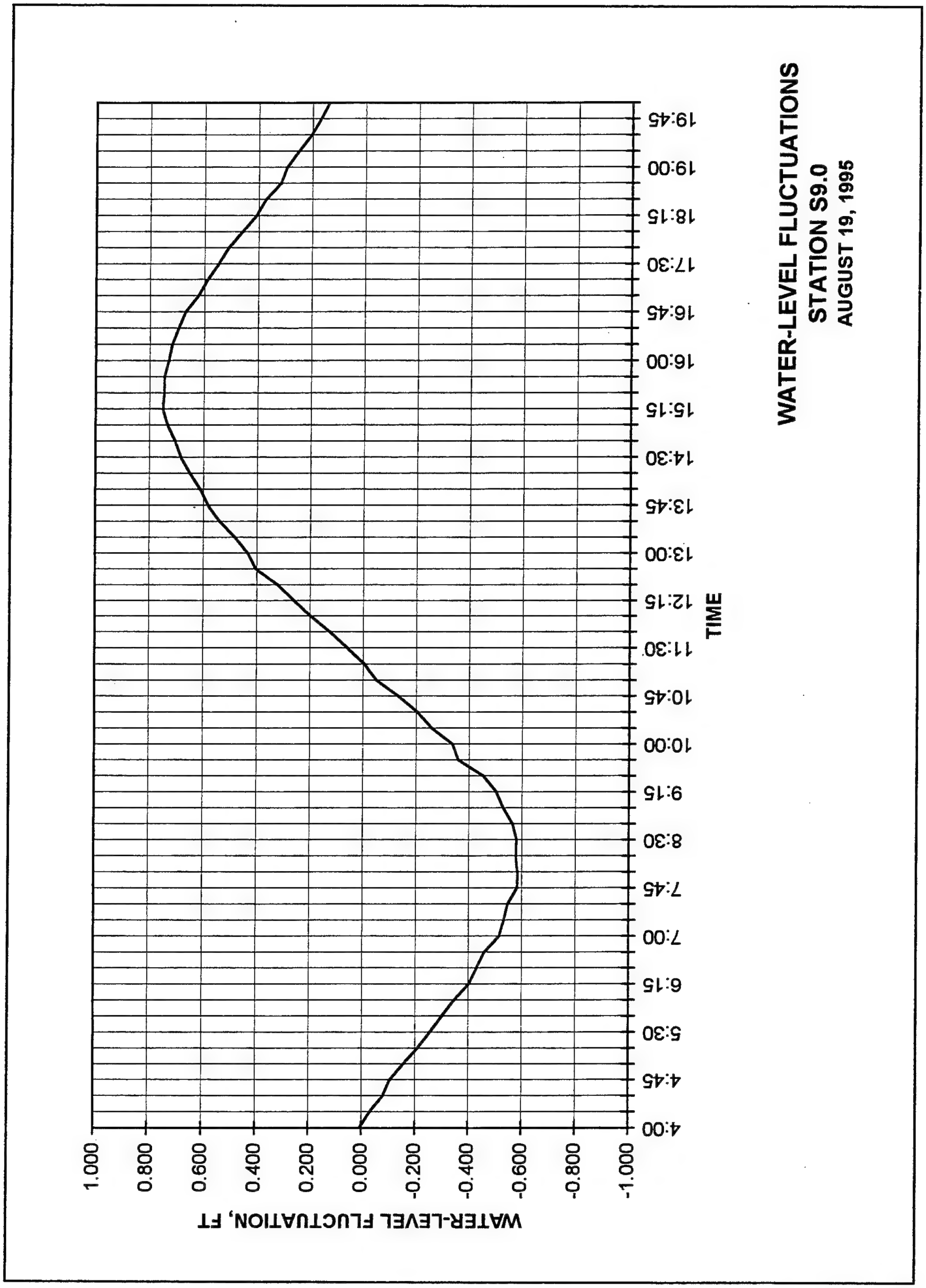
14:30
15:15
16:00
16:45
17:30
18:15
19:00
19:45

Plate 22


WATER-LEVEL FLUCTUATIONS
STATION S9.0
AUGUST 19, 1995
WATER-LEVEL FLUCTUATION, FT
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0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
TIME
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
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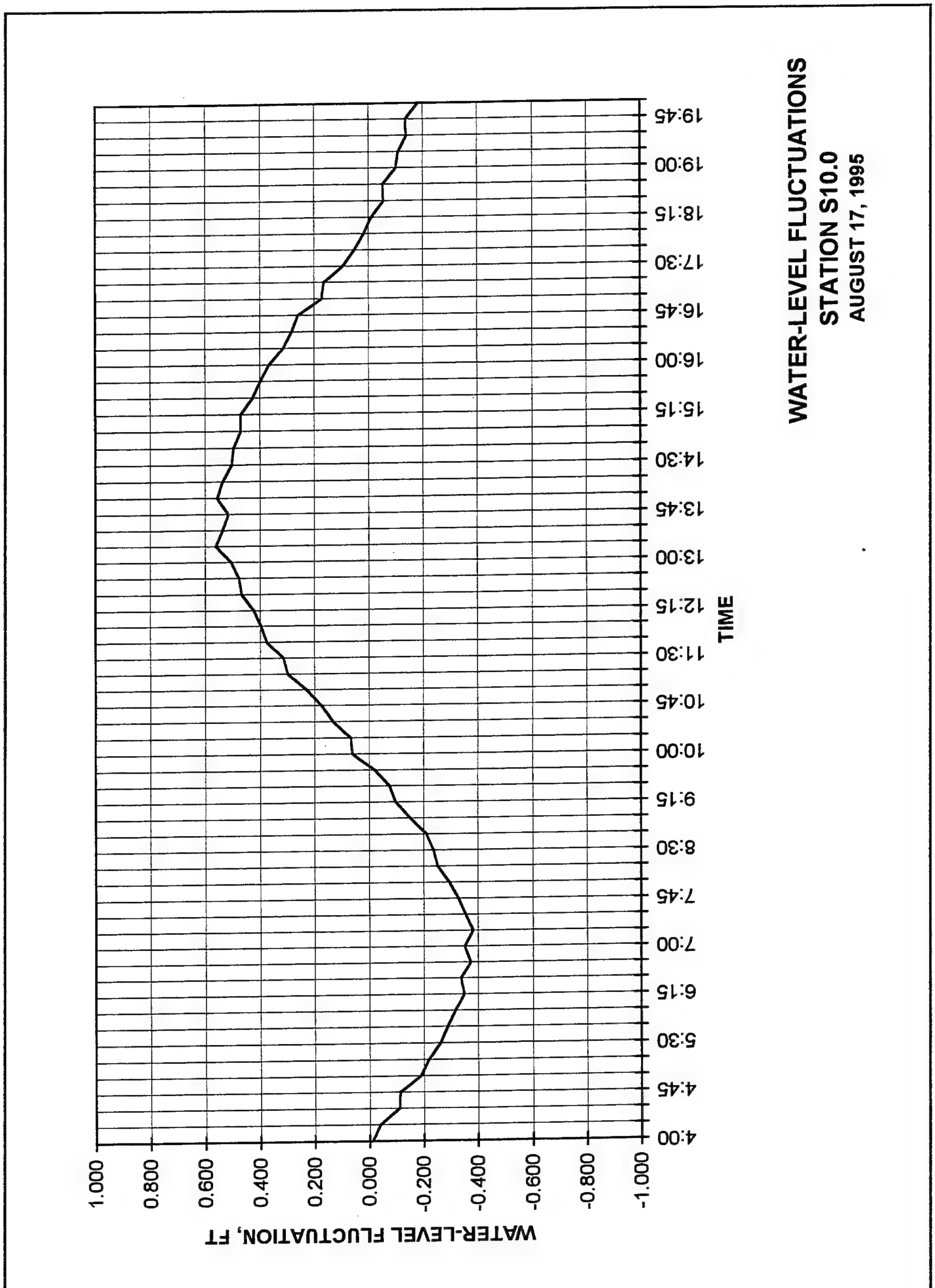
18:15
19:00
19:45


WATER-LEVEL FLUCTUATIONS
STATION S10.0
AUGUST 17, 1995
WATER-LEVEL FLUCTUATION, FT
TIME
1.000
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0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
11:30
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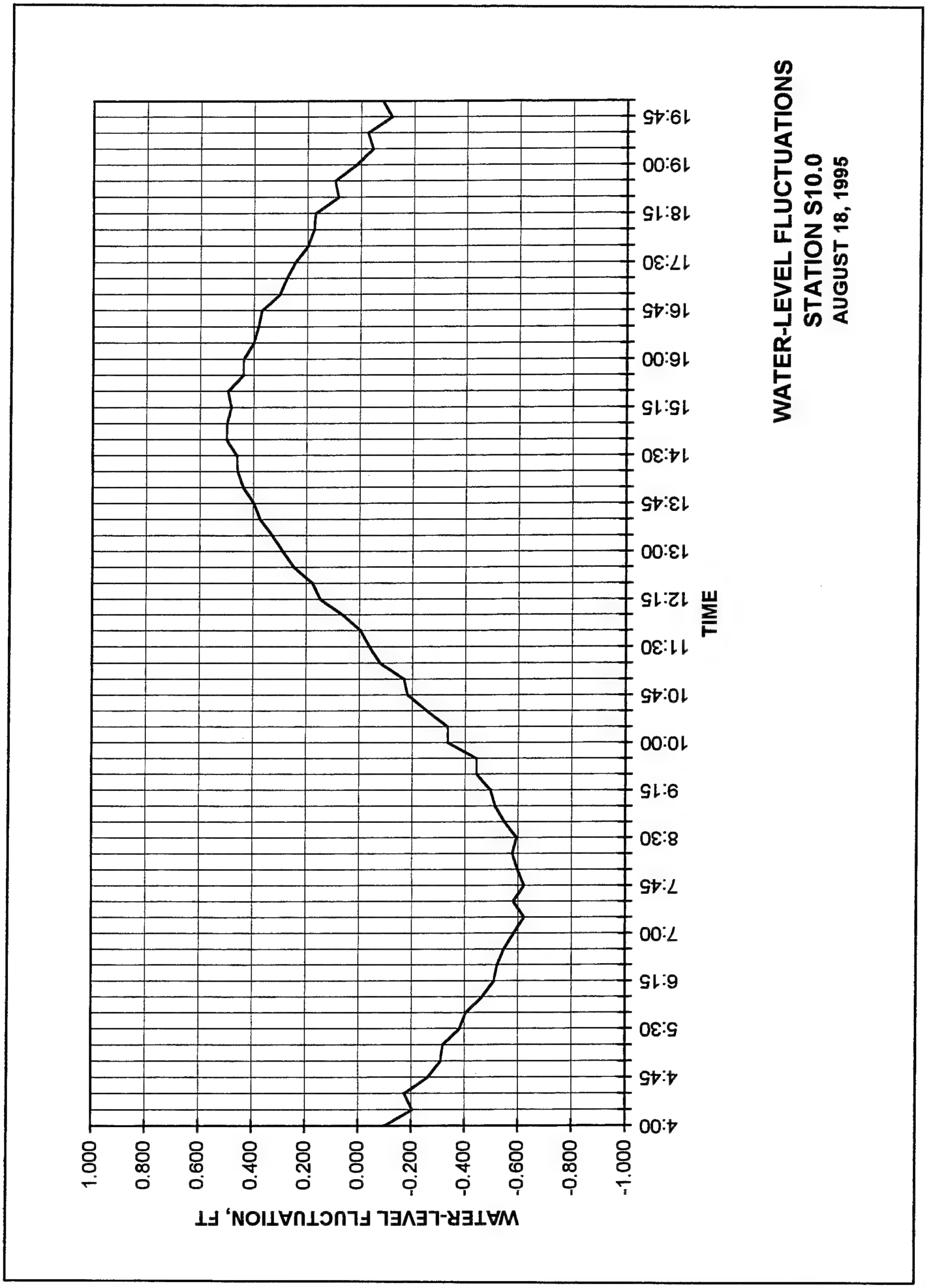
16:00
16:45
17:30
18:15
19:00
19:45

Plate 24


WATER-LEVEL FLUCTUATIONS
STATION S10.0
AUGUST 18, 1995
WATER-LEVEL FLUCTUATION, FT
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0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
TIME
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
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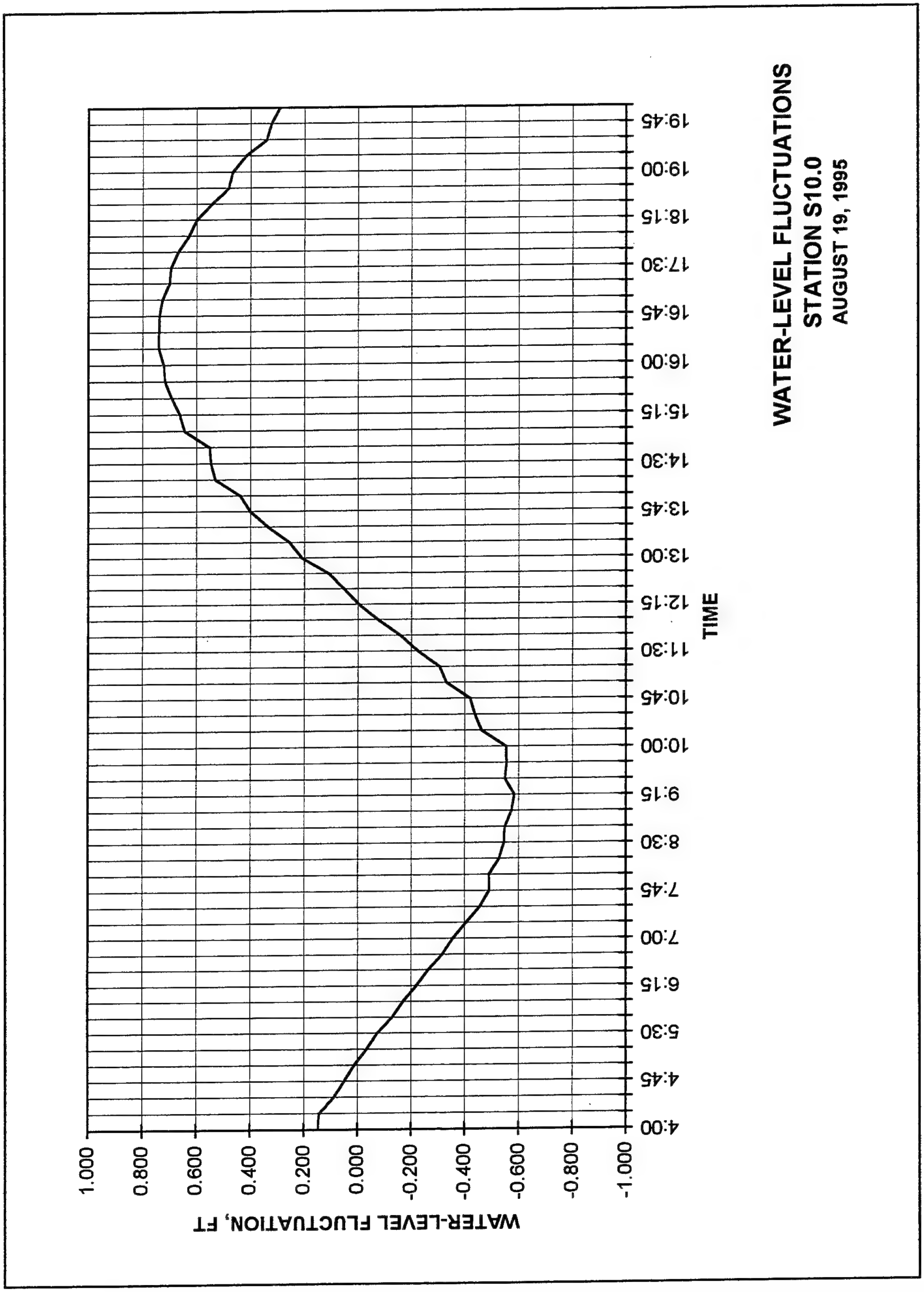
18:15
19:00
19:45


WATER-LEVEL FLUCTUATIONS
STATION S10.0
AUGUST 19, 1995
WATER-LEVEL FLUCTUATION, FT
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0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
TIME
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
11:30
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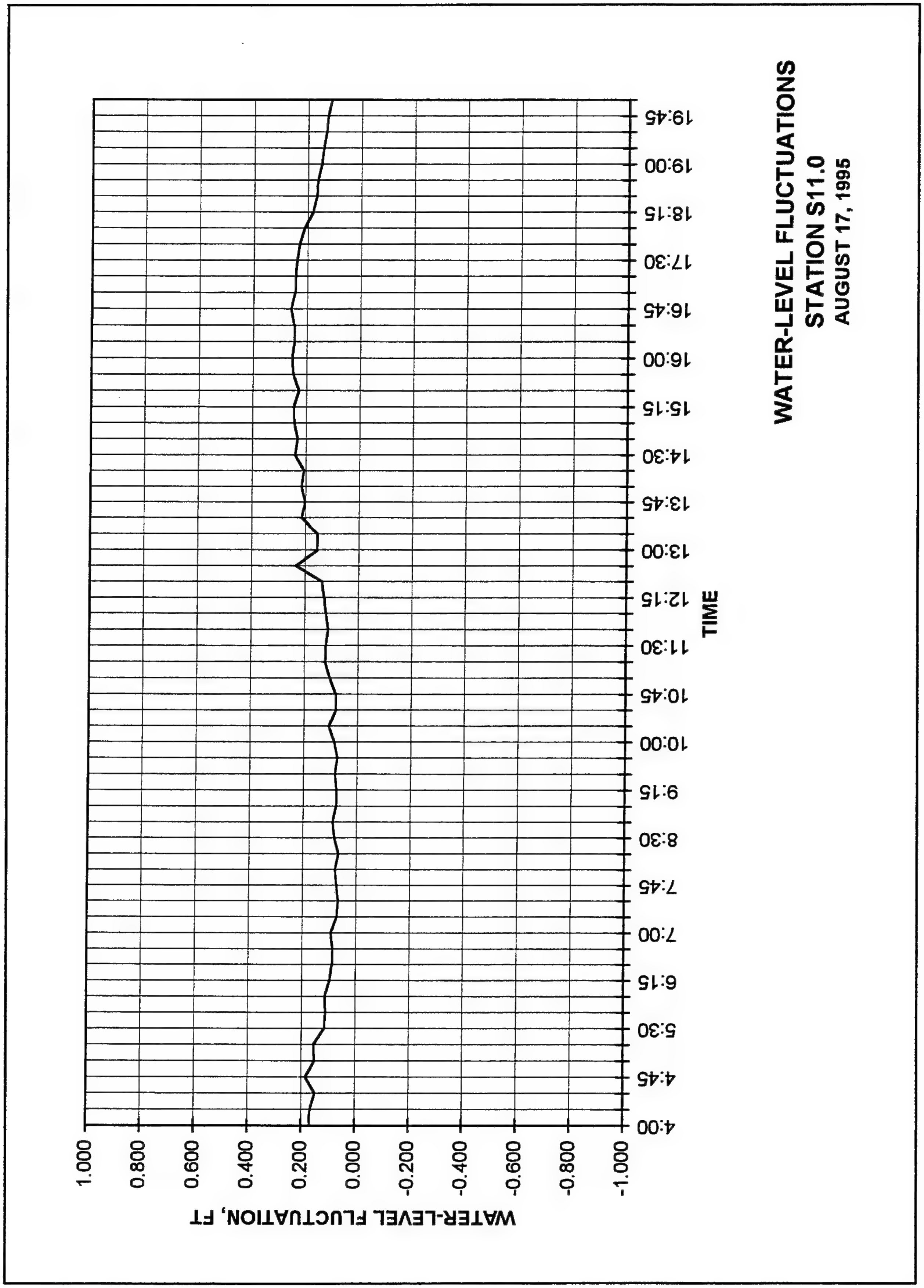
15:15
16:00
16:45
17:30
18:15
19:00
19:45

Plate 26


WATER-LEVEL FLUCTUATIONS
STATION S11.0
AUGUST 17, 1995
WATER-LEVEL FLUCTUATION, FT
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0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
TIME
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
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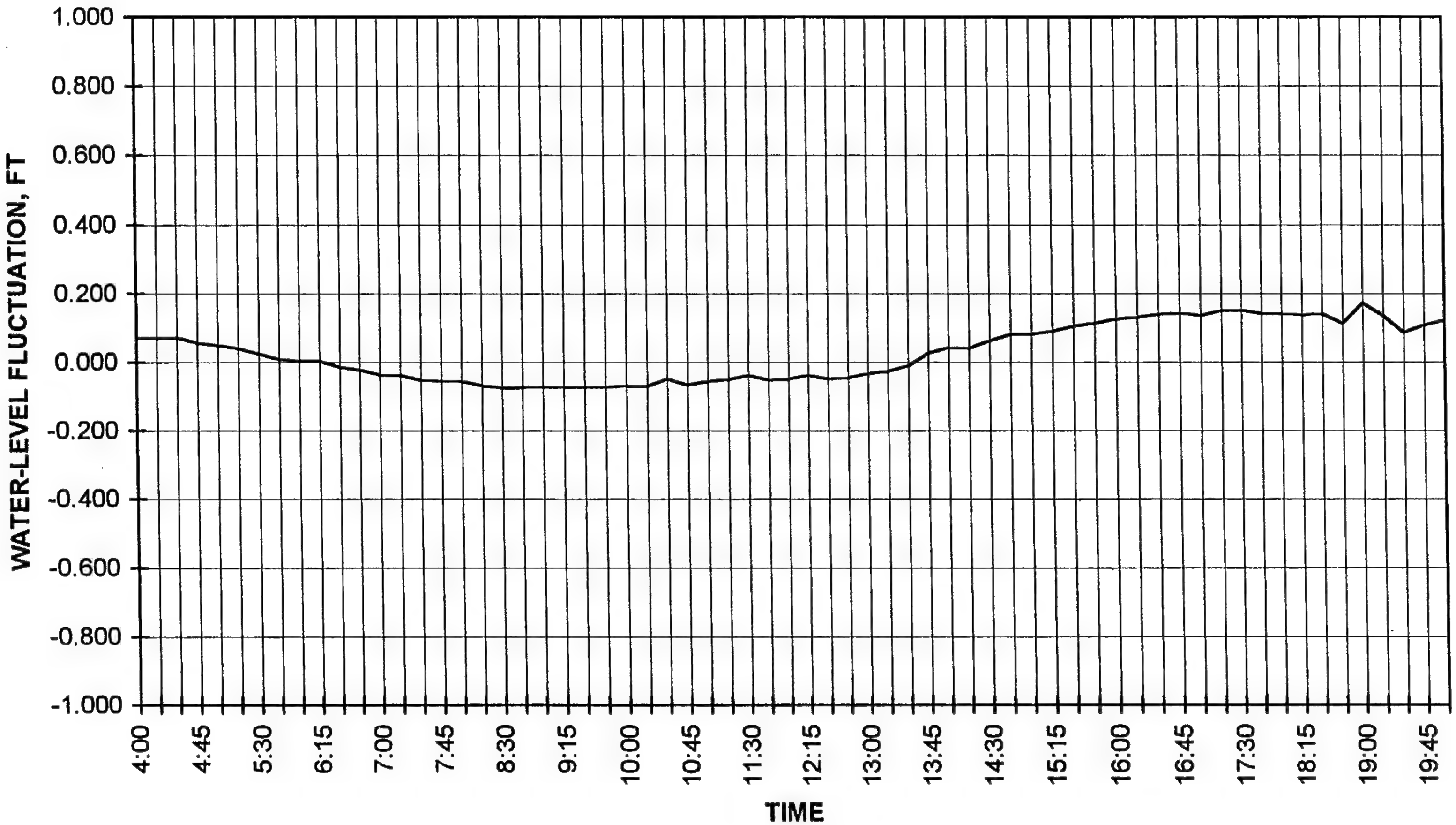
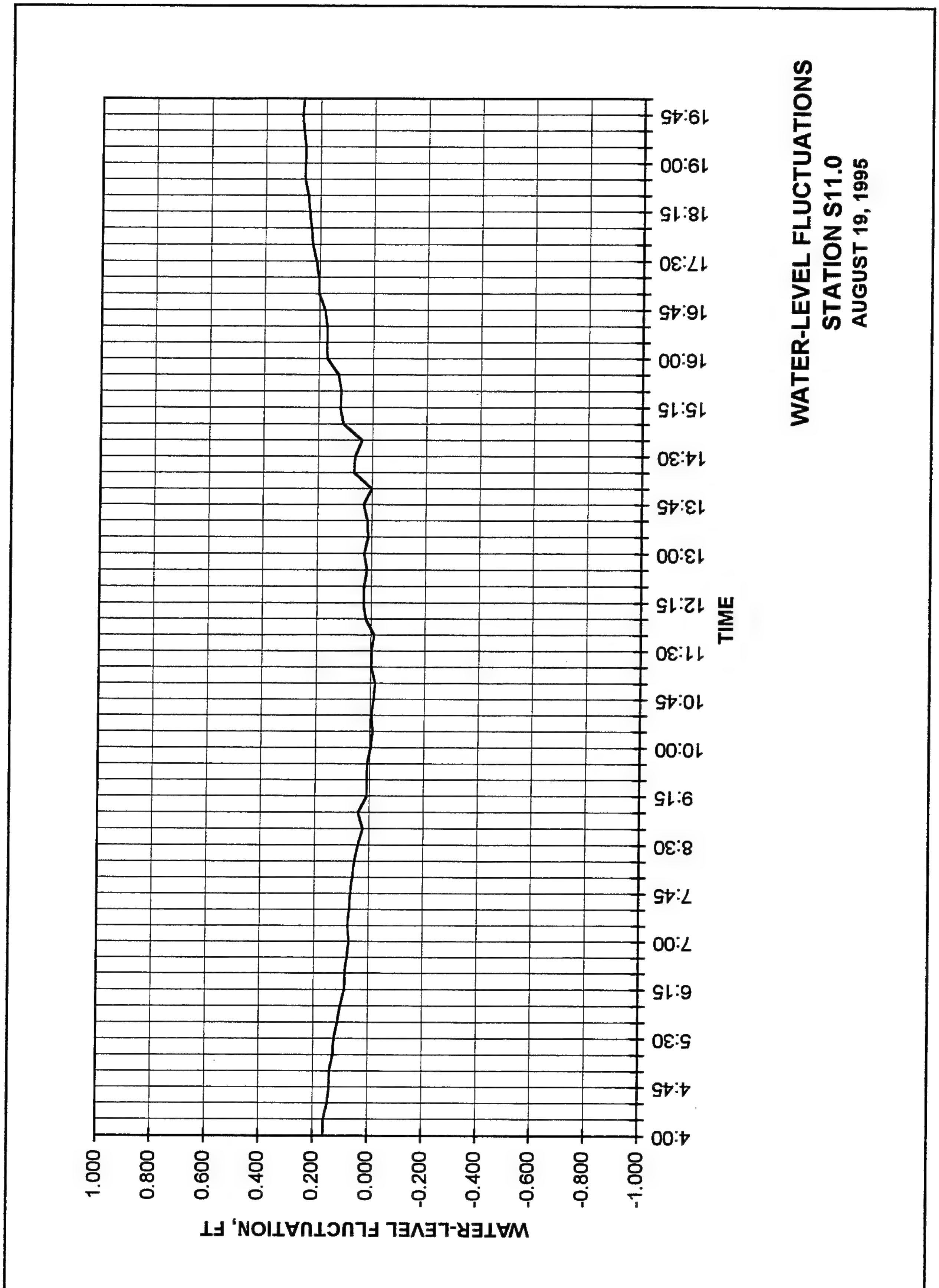
18:15
19:00
19:45



WATER-LEVEL FLUCTUATIONS
STATION S11.0
AUGUST 18, 1995


WATER-LEVEL FLUCTUATIONS
STATION S11.0
AUGUST 19, 1995
WATER-LEVEL FLUCTUATION, FT
1.000
0.800
0.600
0.400
0.200
0.000
-0.200
-0.400
-0.600
-0.800
-1.000
TIME
4:00
4:45
5:30
6:15
7:00
7:45
8:30
9:15
10:00
10:45
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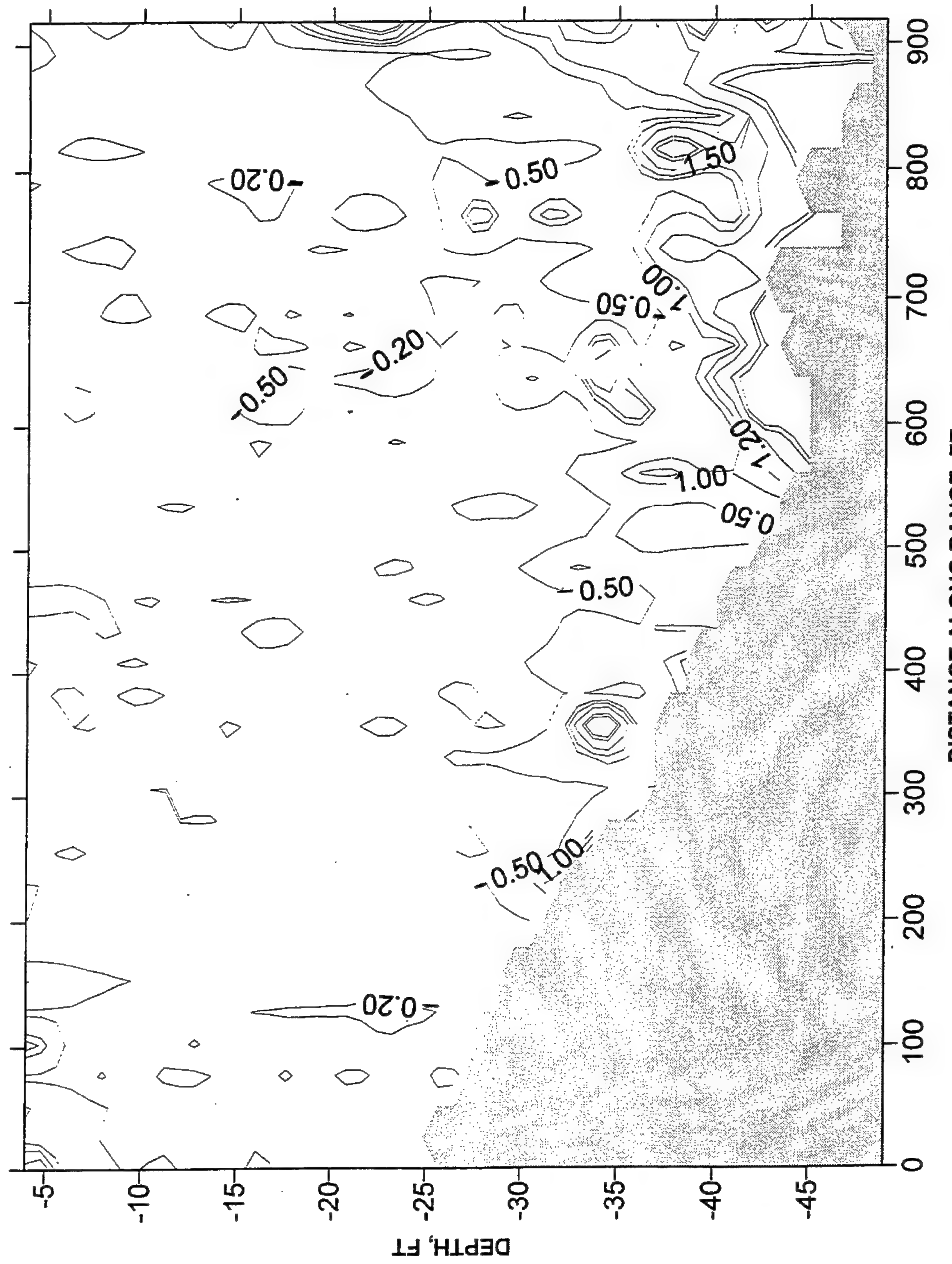
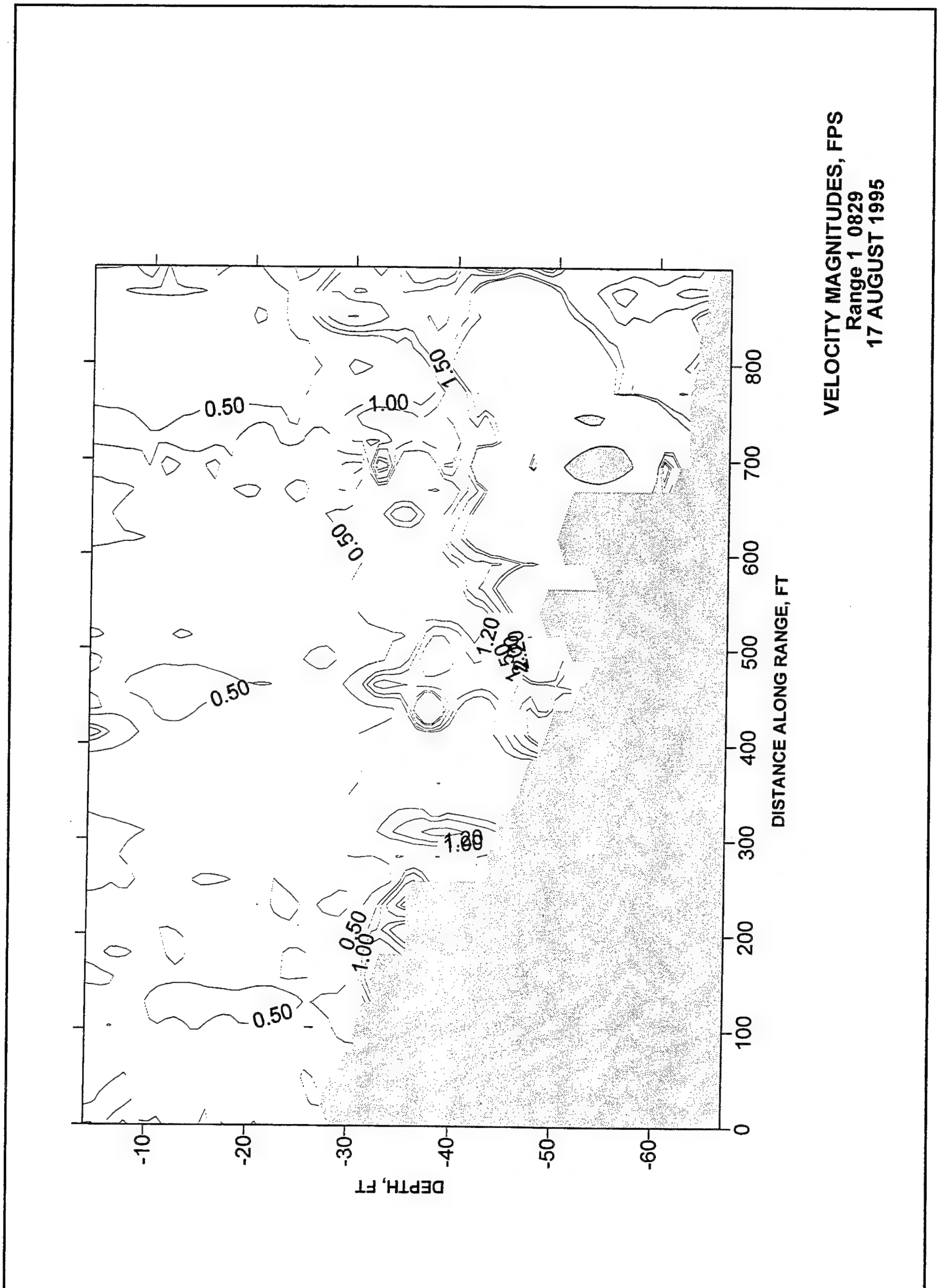
18:15
19:00
19:45



VELOCITY MAGNITUDES, FPS
Range 1 0555
17 AUGUST 1995

Plate 30


VELOCITY MAGNITUDES, FPS
Range 1 0829
17 AUGUST 1995
DISTANCE ALONG RANGE, FT
DEPTH, FT
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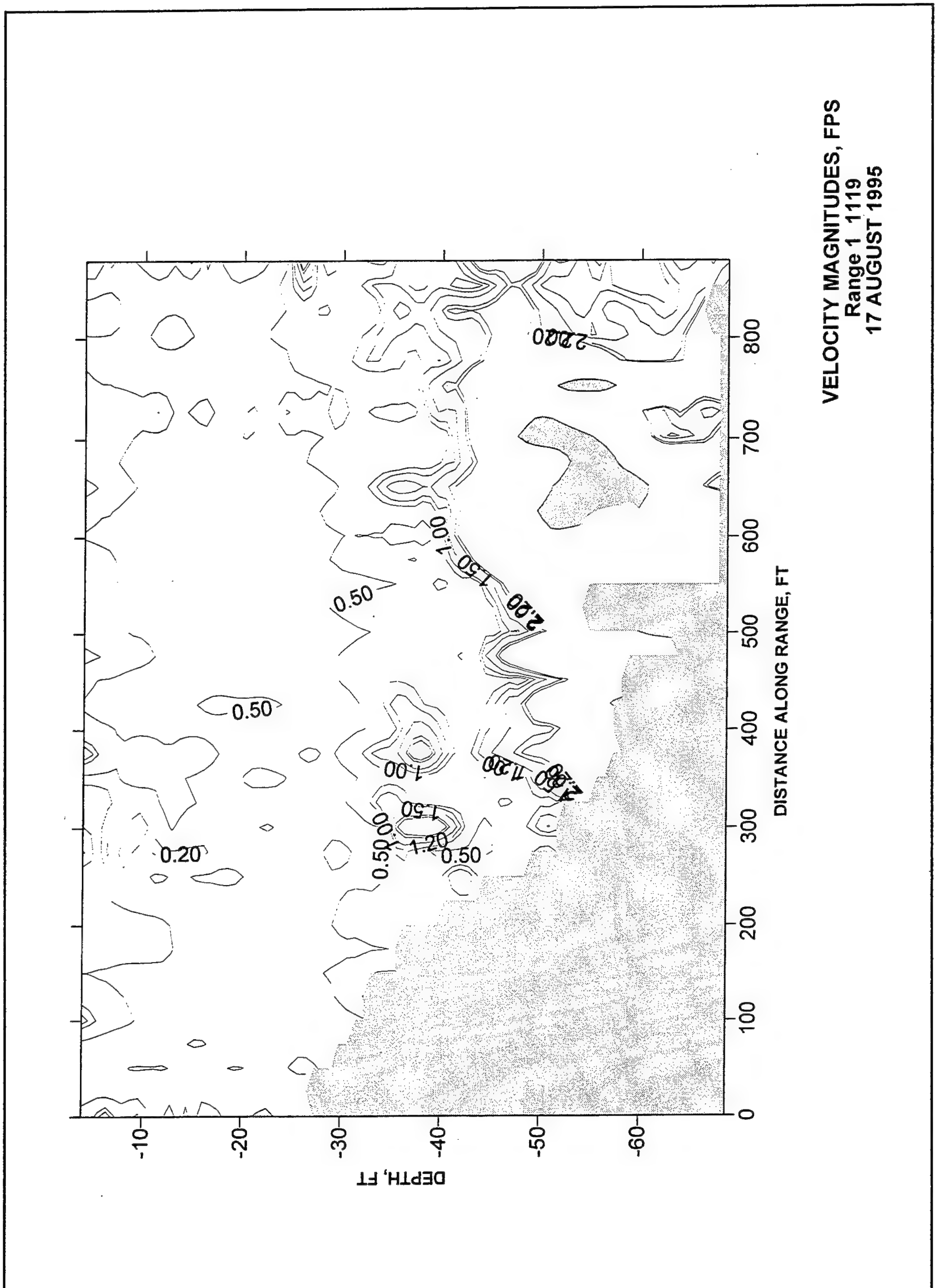
100
200
300
400
500
600
700
800
-10
-20
-30
-40
-50
-60
0.50
1.00
1.50
1.20
2.00


VELOCITY MAGNITUDES, FPS
Range 1 1119
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DEPTH, FT
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200
300
400
500
600
700
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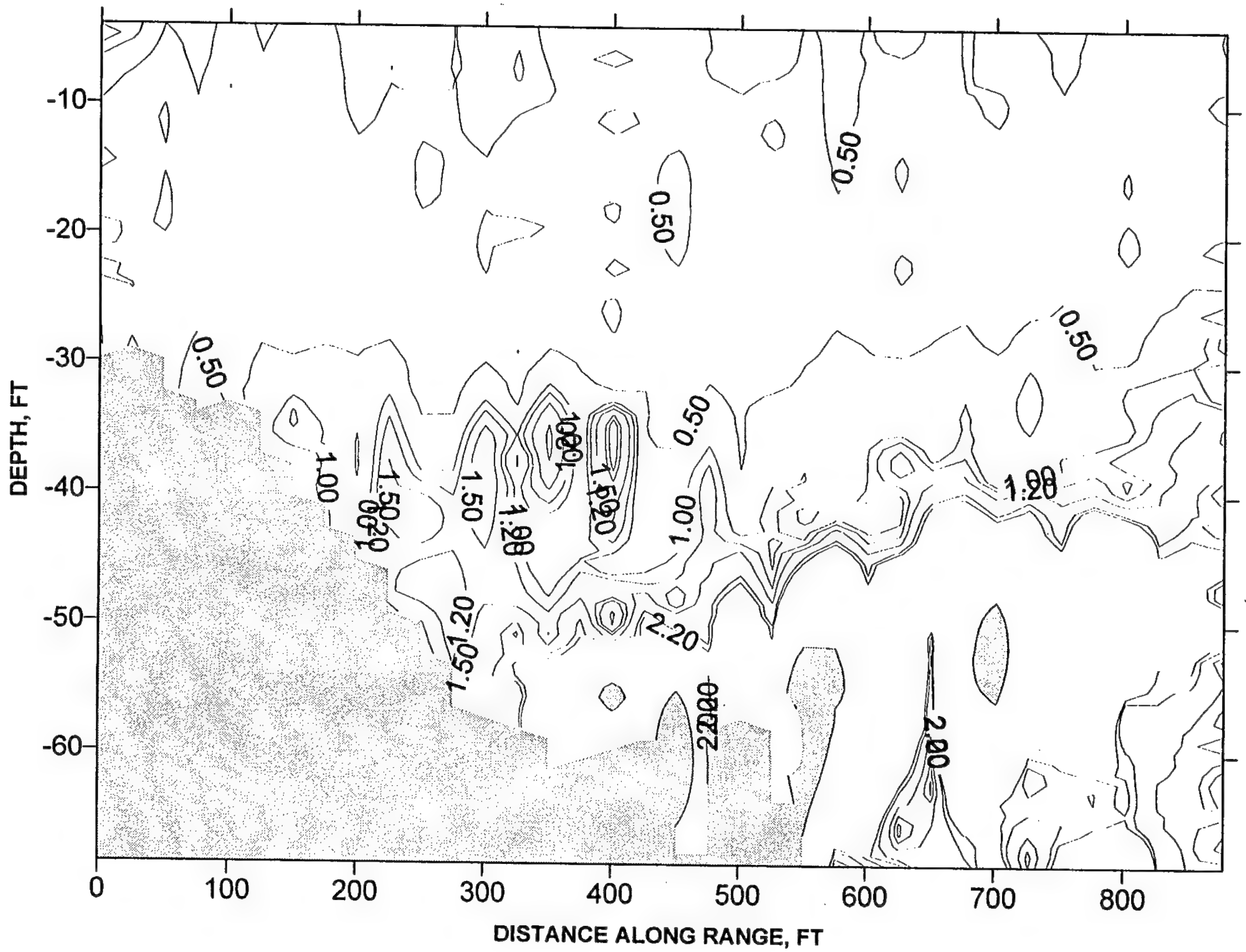
-40
-50
-60
0.20
0.50
1.00
1.20
1.50
2.00

Plate 32



VELOCITY MAGNITUDES, FPS
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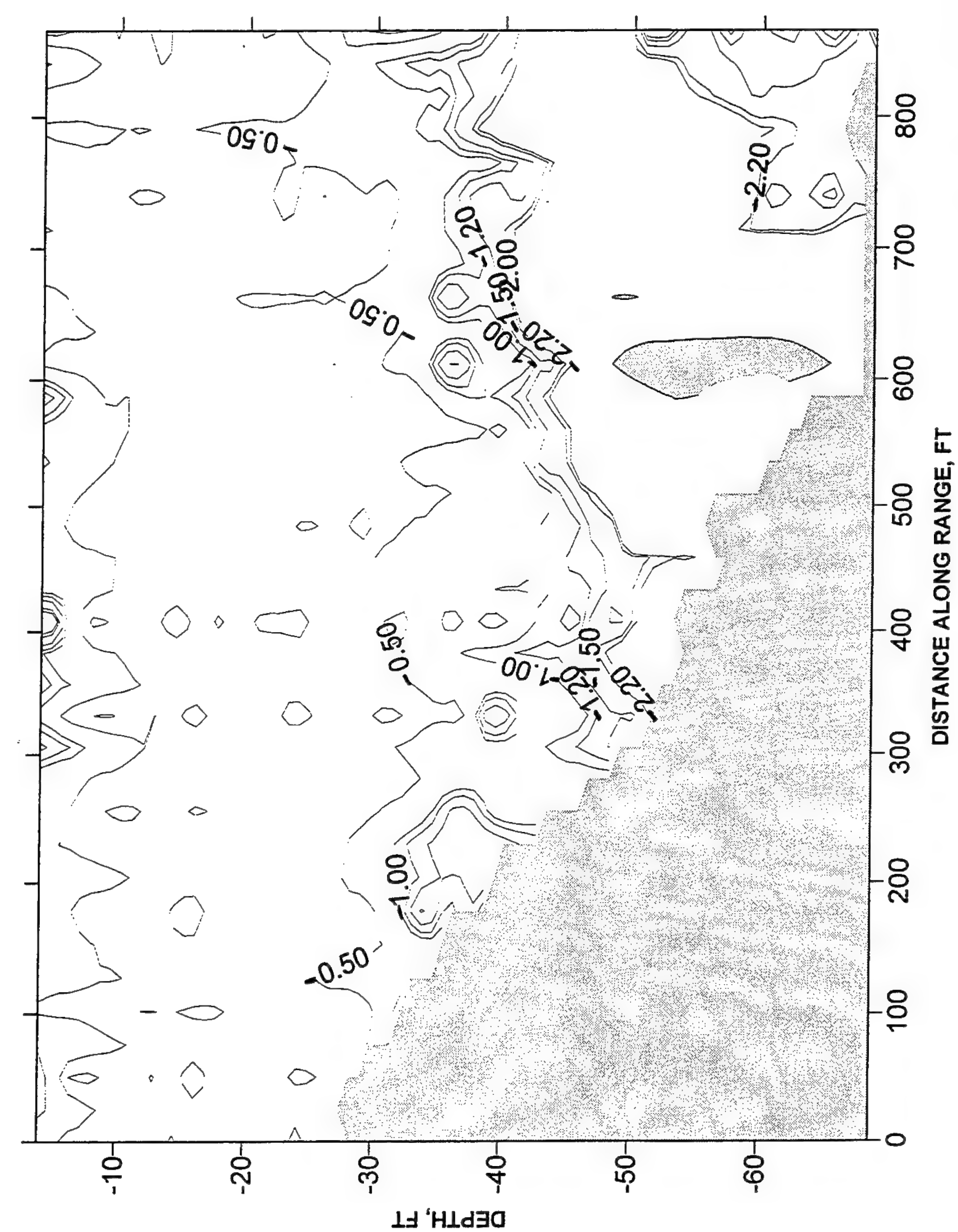
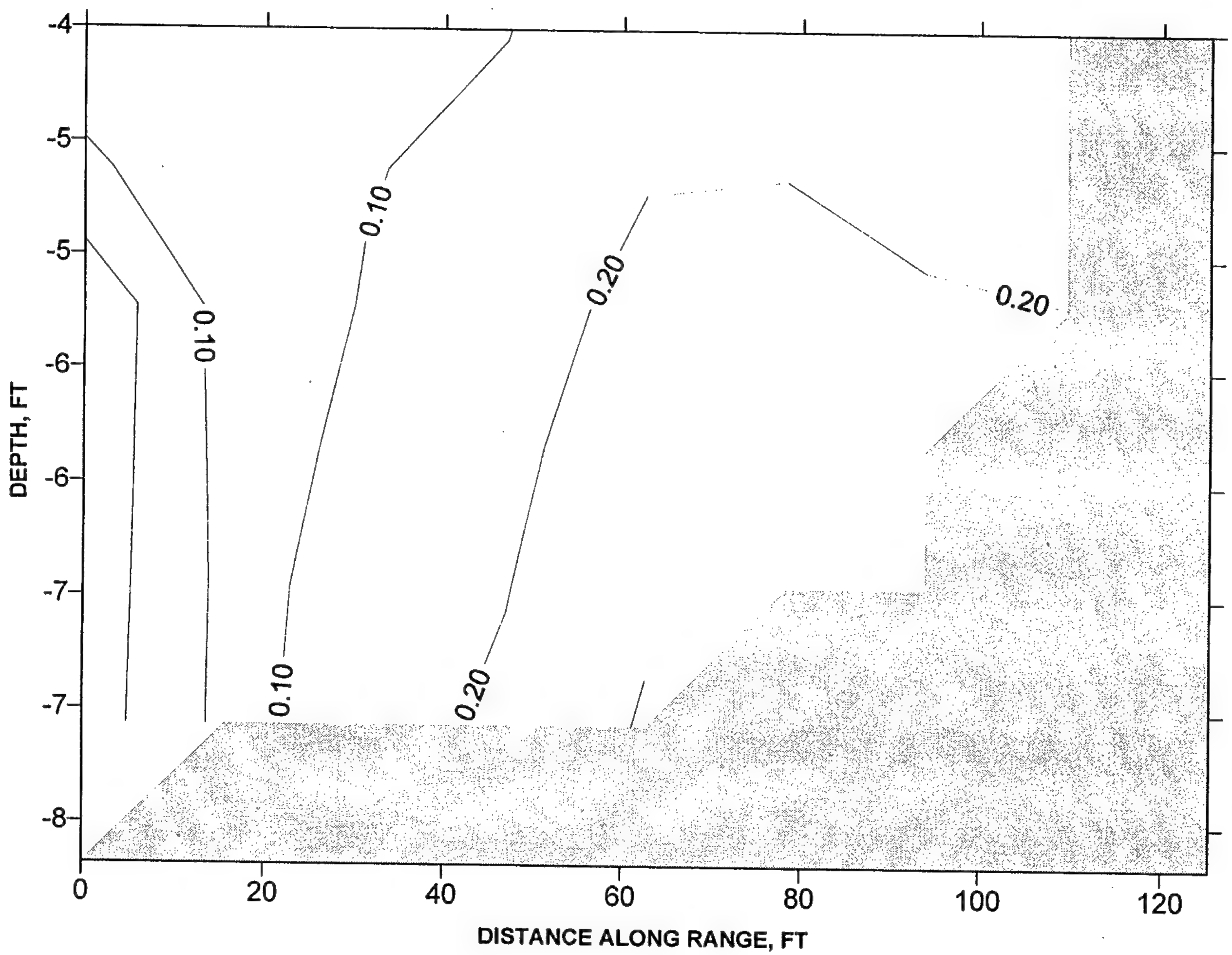


VELOCITY MAGNITUDES, FPS
Range 1 1547
17 AUGUST 1995



VELOCITY MAGNITUDES, FPS
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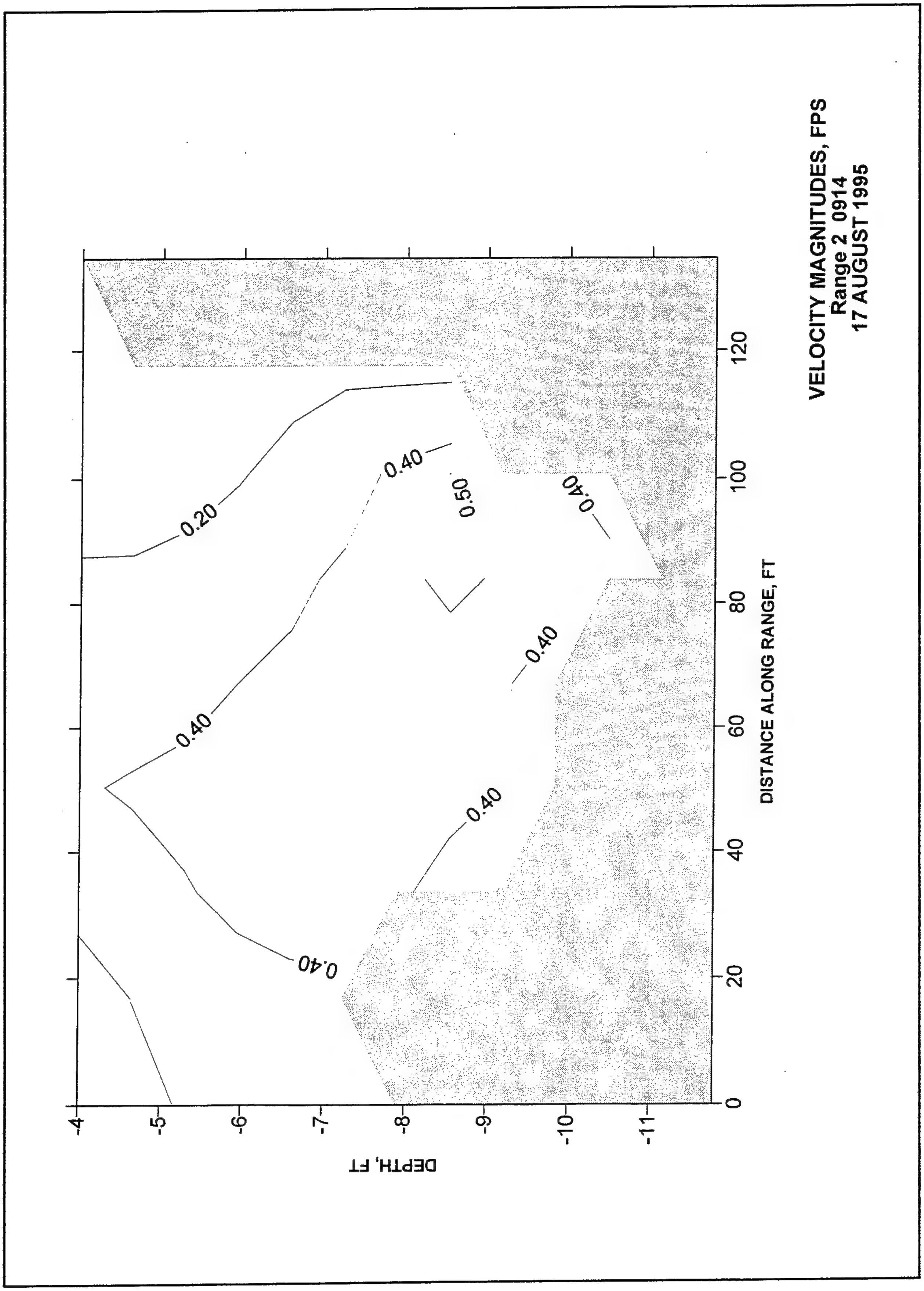
17 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 2 0914
17 AUGUST 1995
DEPTH, FT
DISTANCE ALONG RANGE, FT
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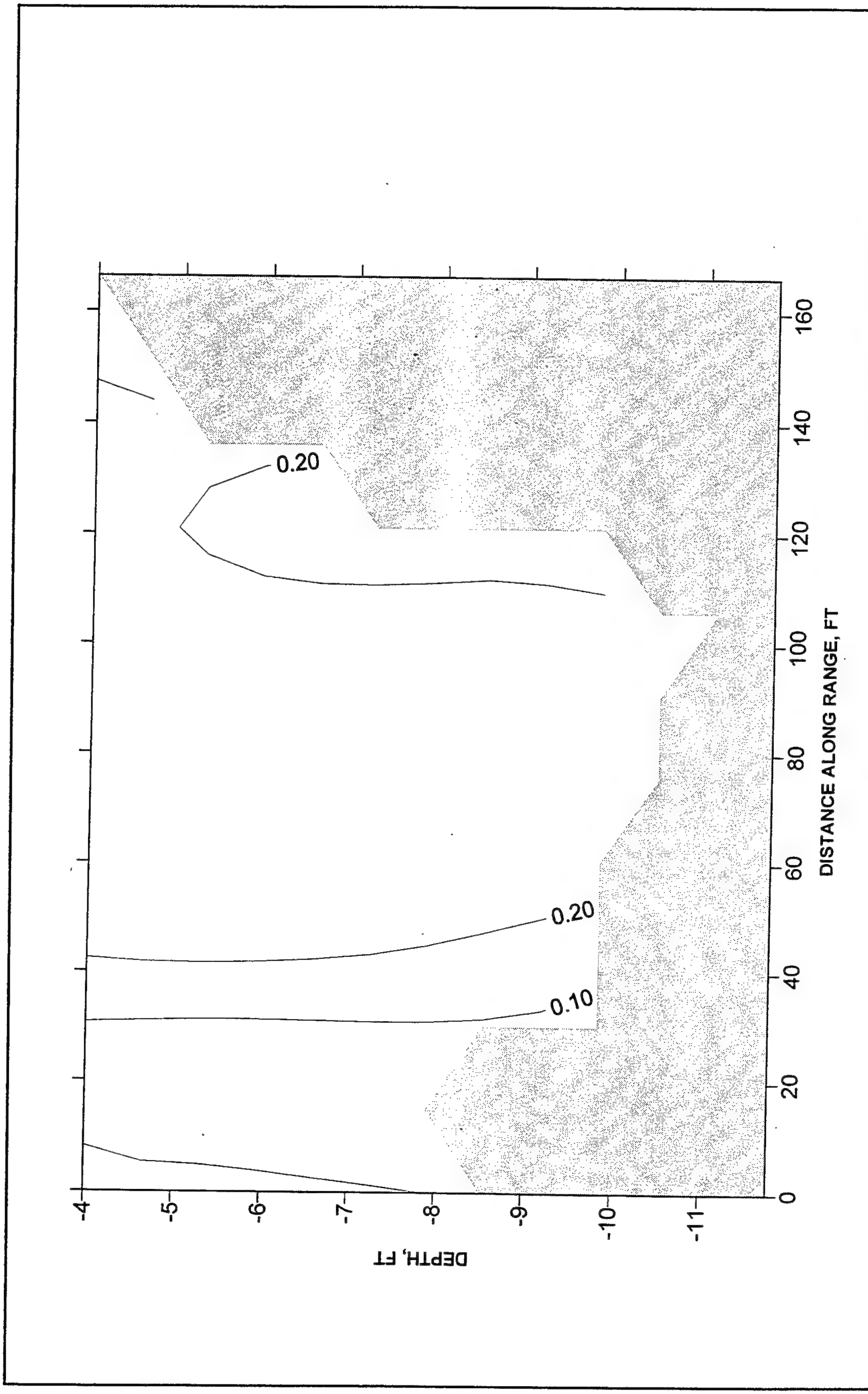
-5
-6
-7
-8
-9
-10
-11
0
20
40
60
80
100
120
0.20
0.40
0.40
0.40
0.40
0.40
0.40
0.50

Plate 36



VELOCITY MAGNITUDES, FPS
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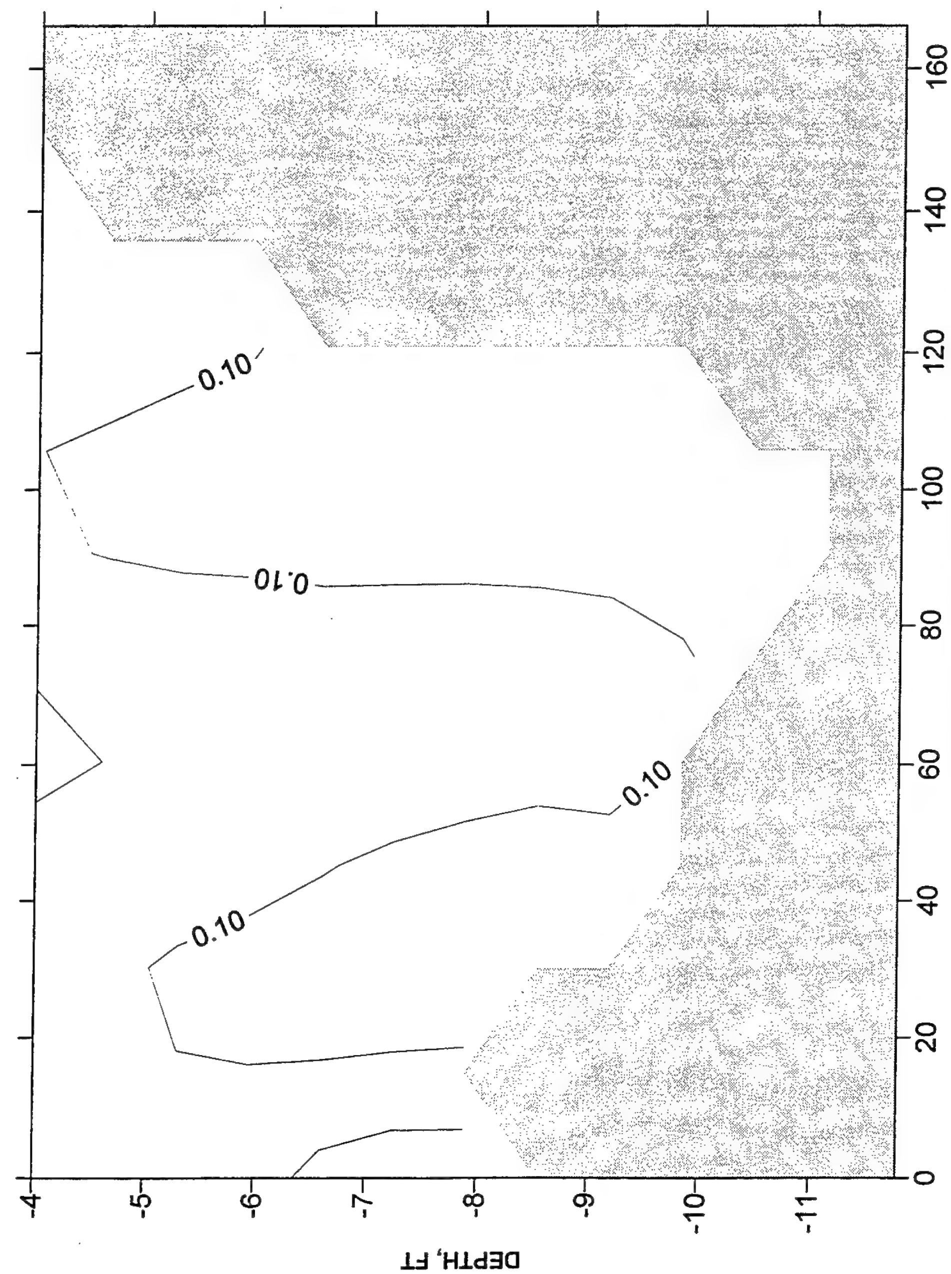
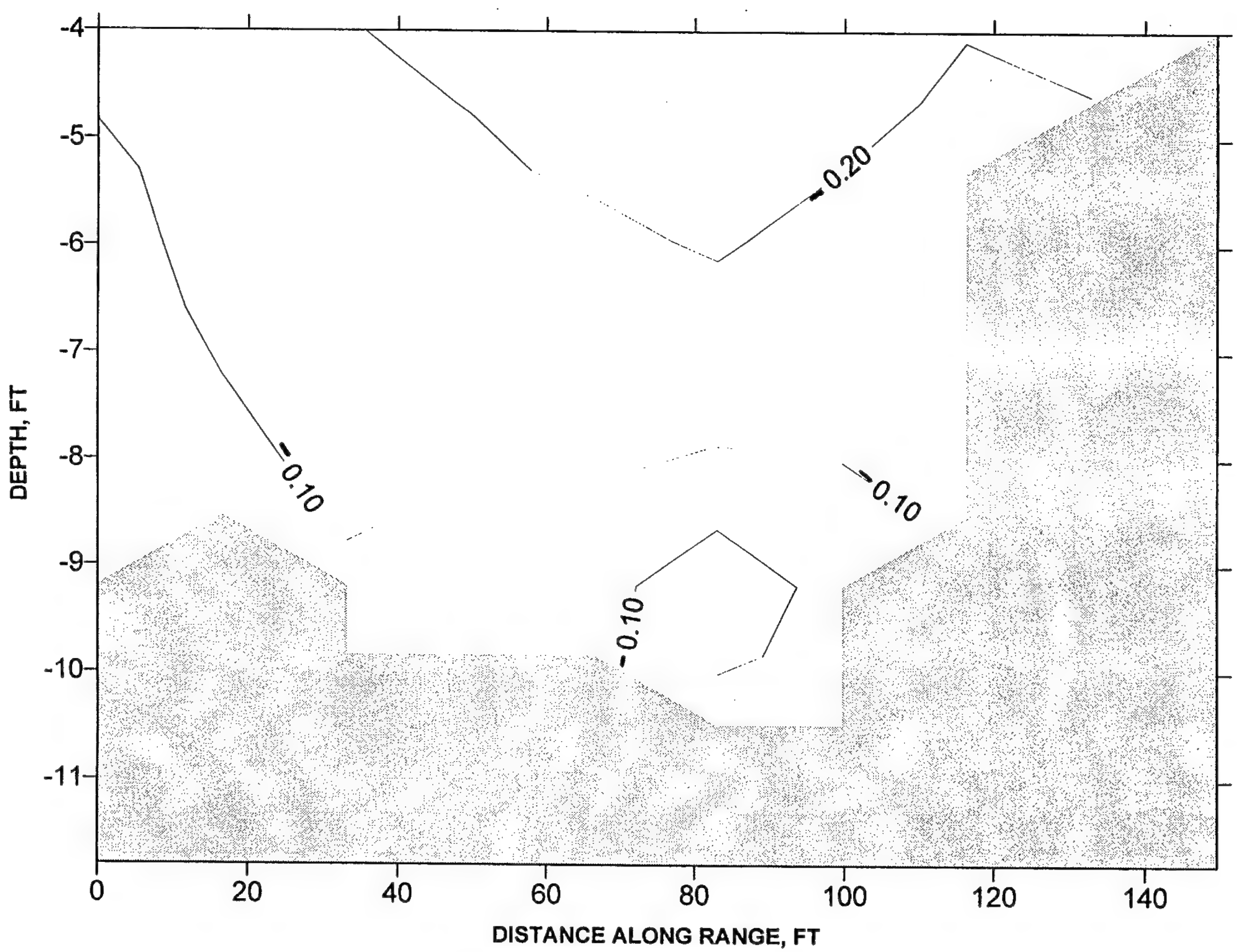
17 AUGUST 1995

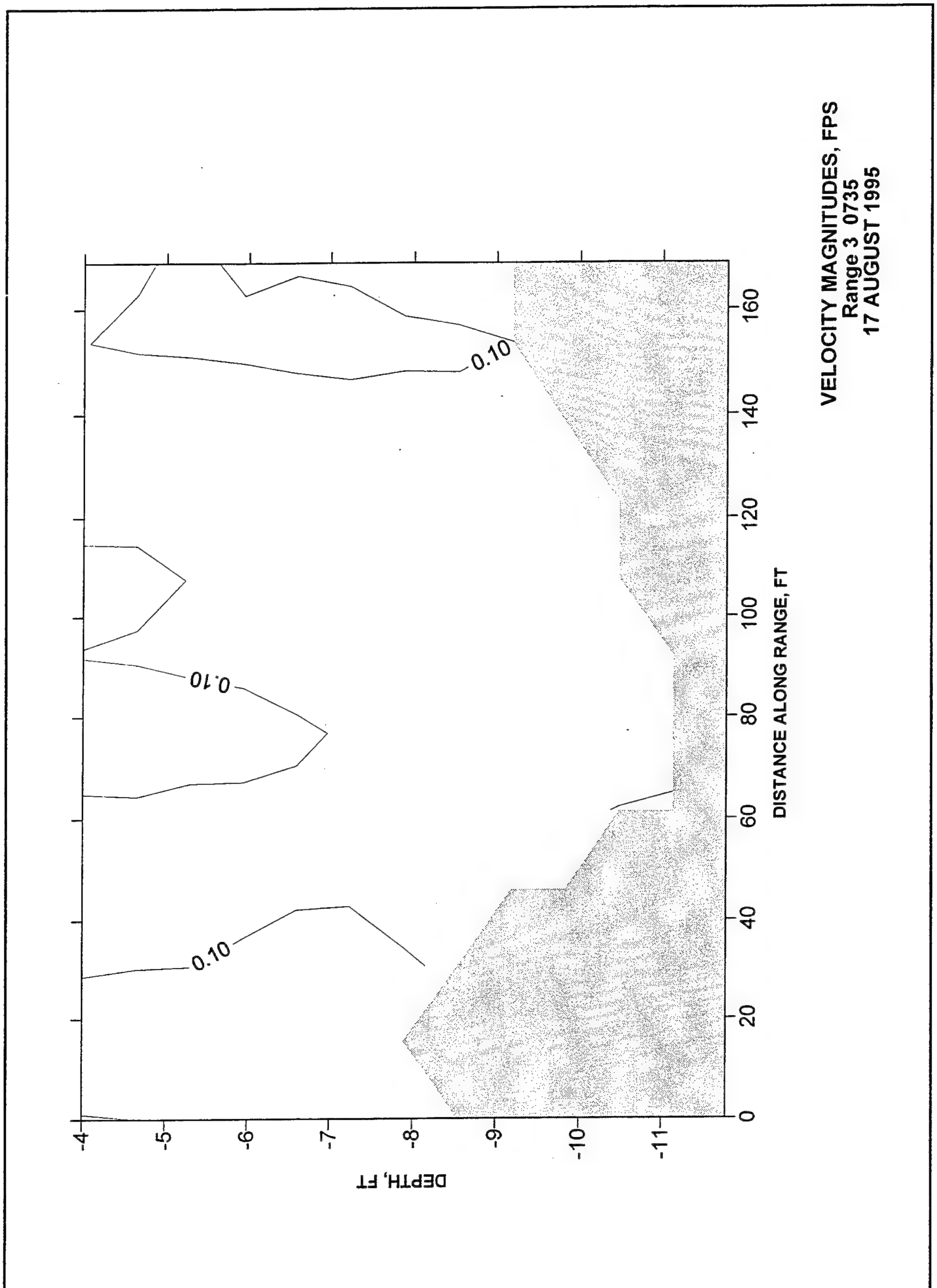


VELOCITY MAGNITUDES, FPS
Range 2 1331
17 AUGUST 1995

Plate 38



VELOCITY MAGNITUDES, FPS
Range 2 1614
17 AUGUST 1995


VELOCITY MAGNITUDES, FPS
Range 3 0735
17 AUGUST 1995
DEPTH, FT
DISTANCE ALONG RANGE, FT
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-5
-6
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-10
-11
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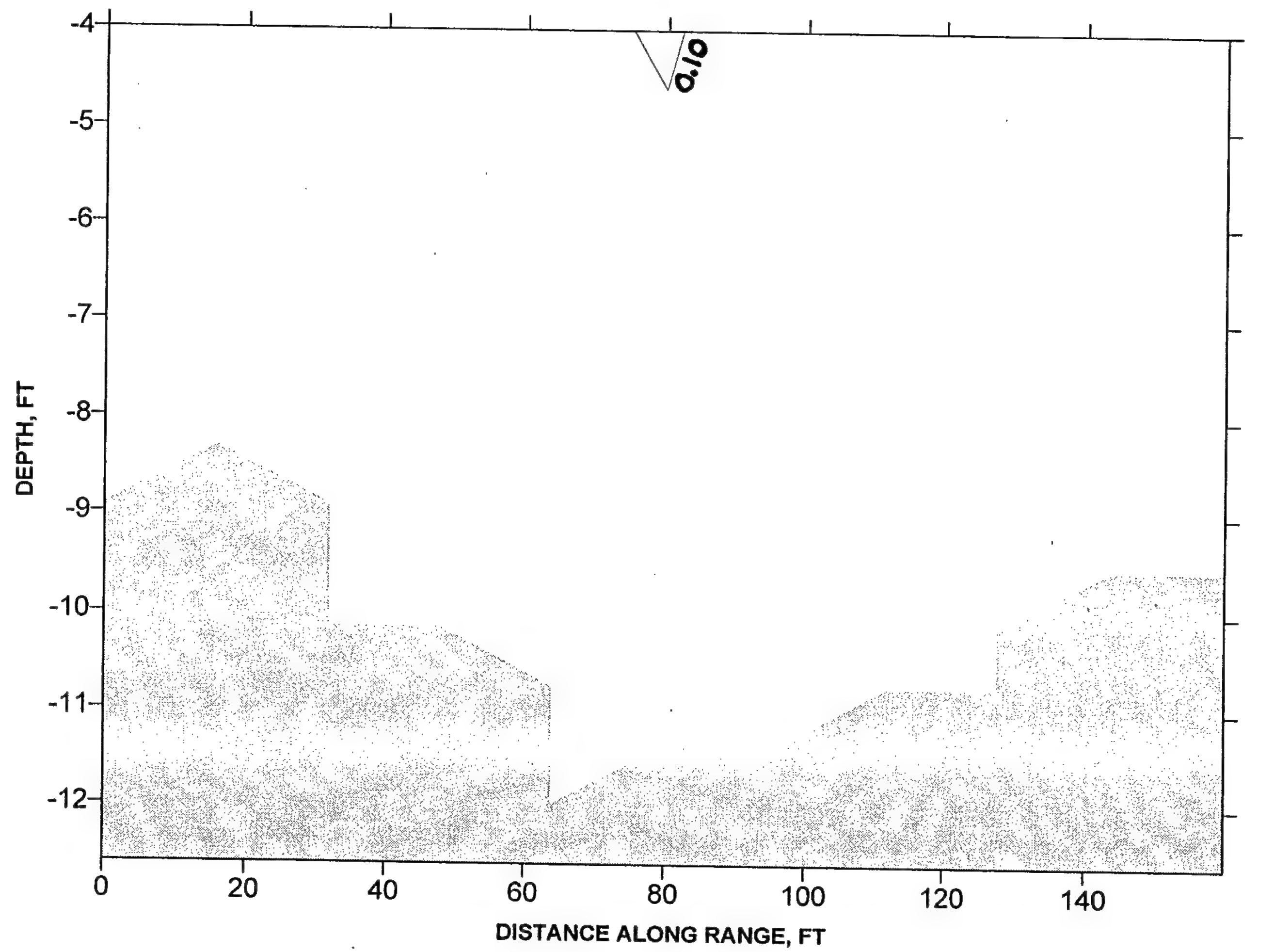
40
60
80
100
120
140
160
0.10
0.10
0.10



VELOCITY MAGNITUDES, FPS
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17 AUGUST 1995

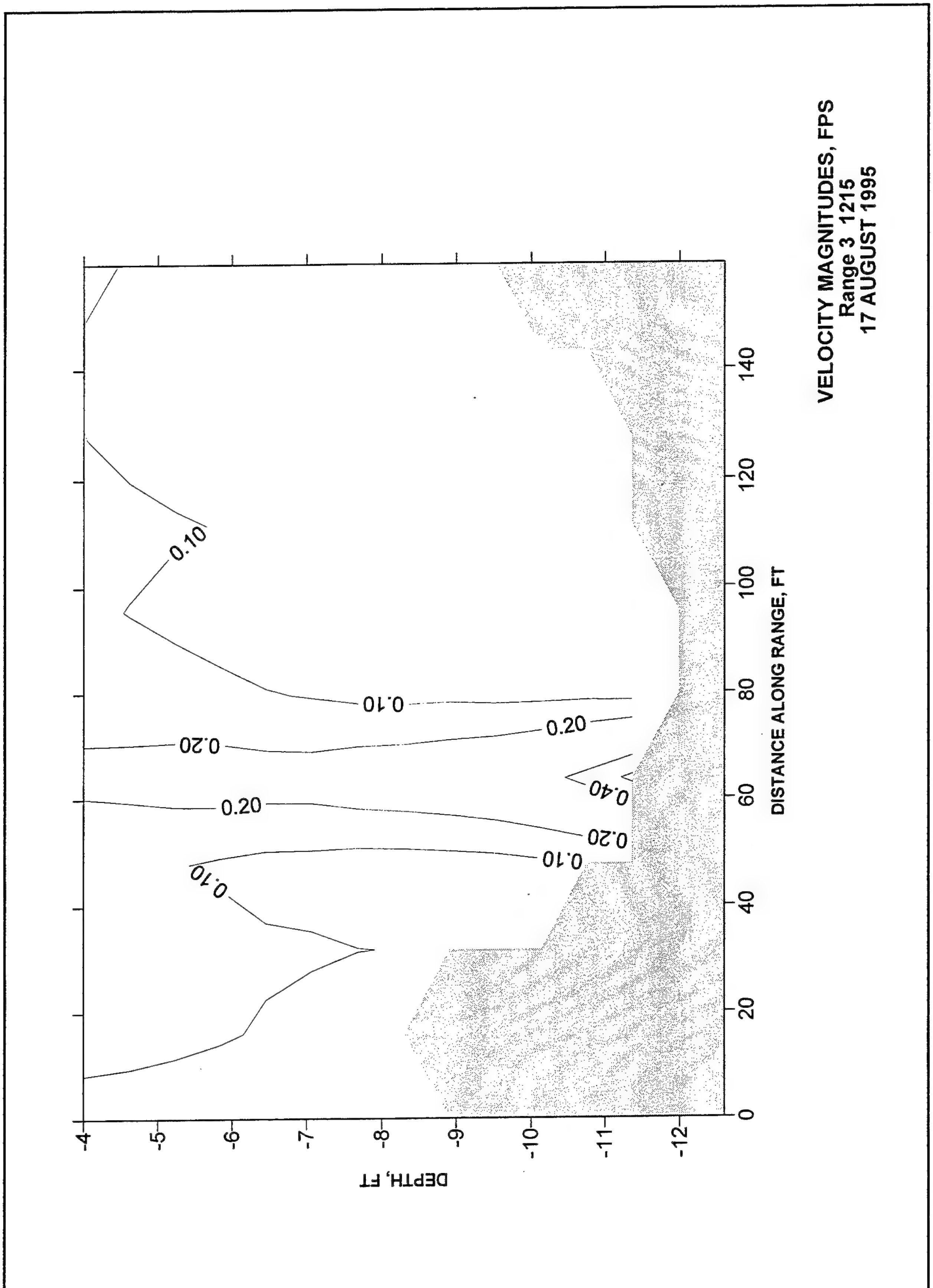
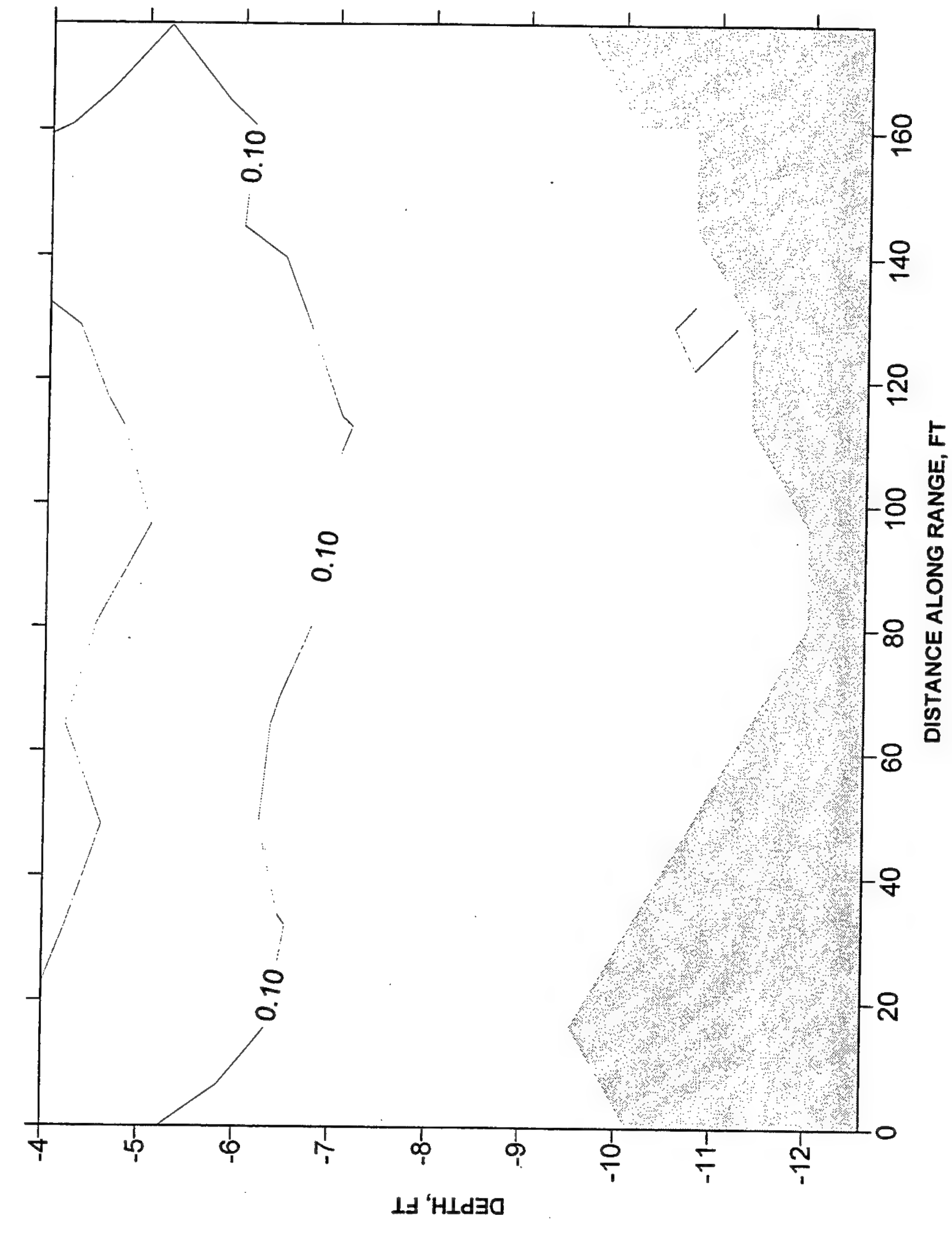
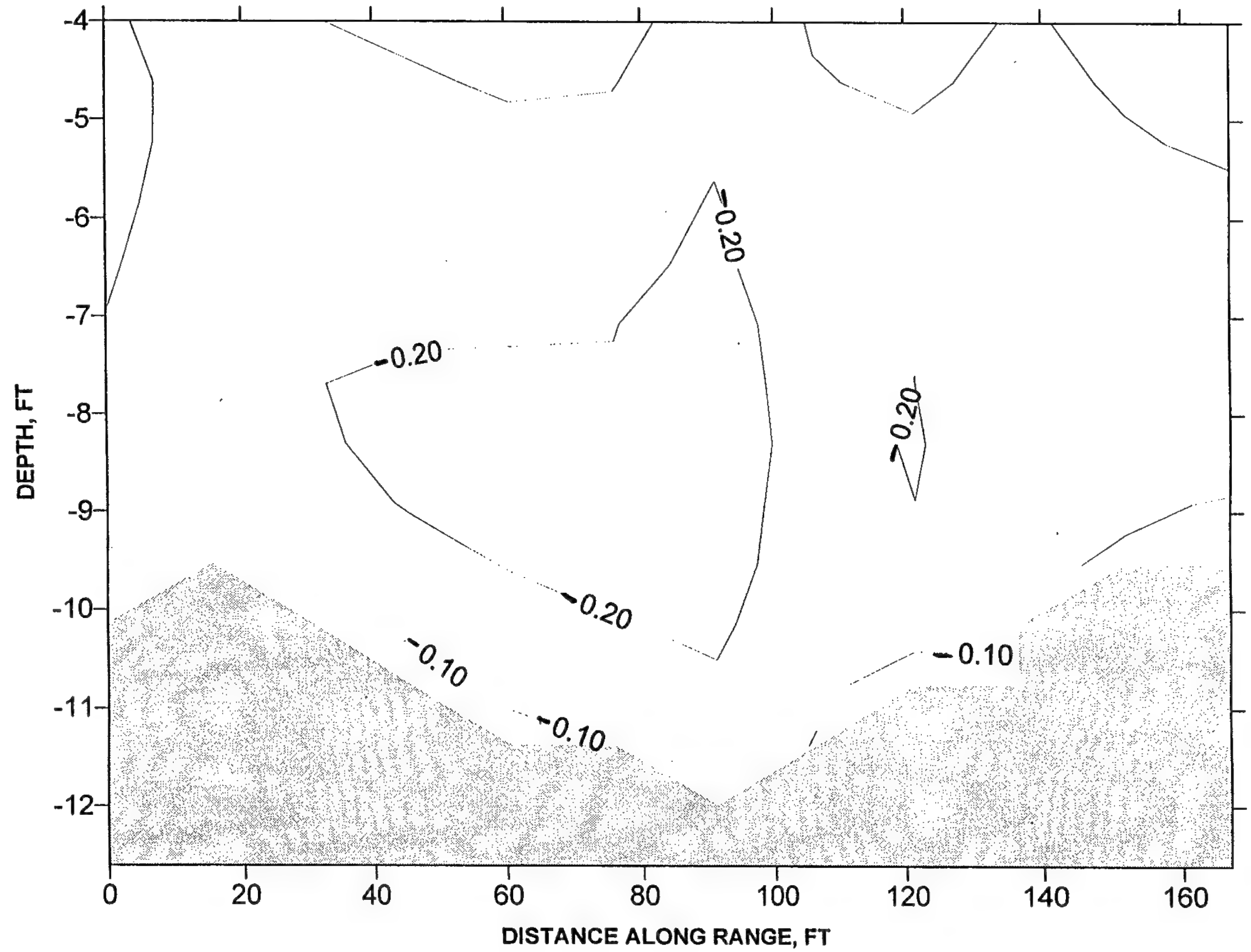

VELOCITY MAGNITUDES, FPS
Range 3 1215
17 AUGUST 1995
DEPTH, FT
DISTANCE ALONG RANGE, FT
-4
-5
-6
-7
-8
-9
-10
-11
-12
0
20
40
60
80
100
120
140
0.10
0.20
0.40

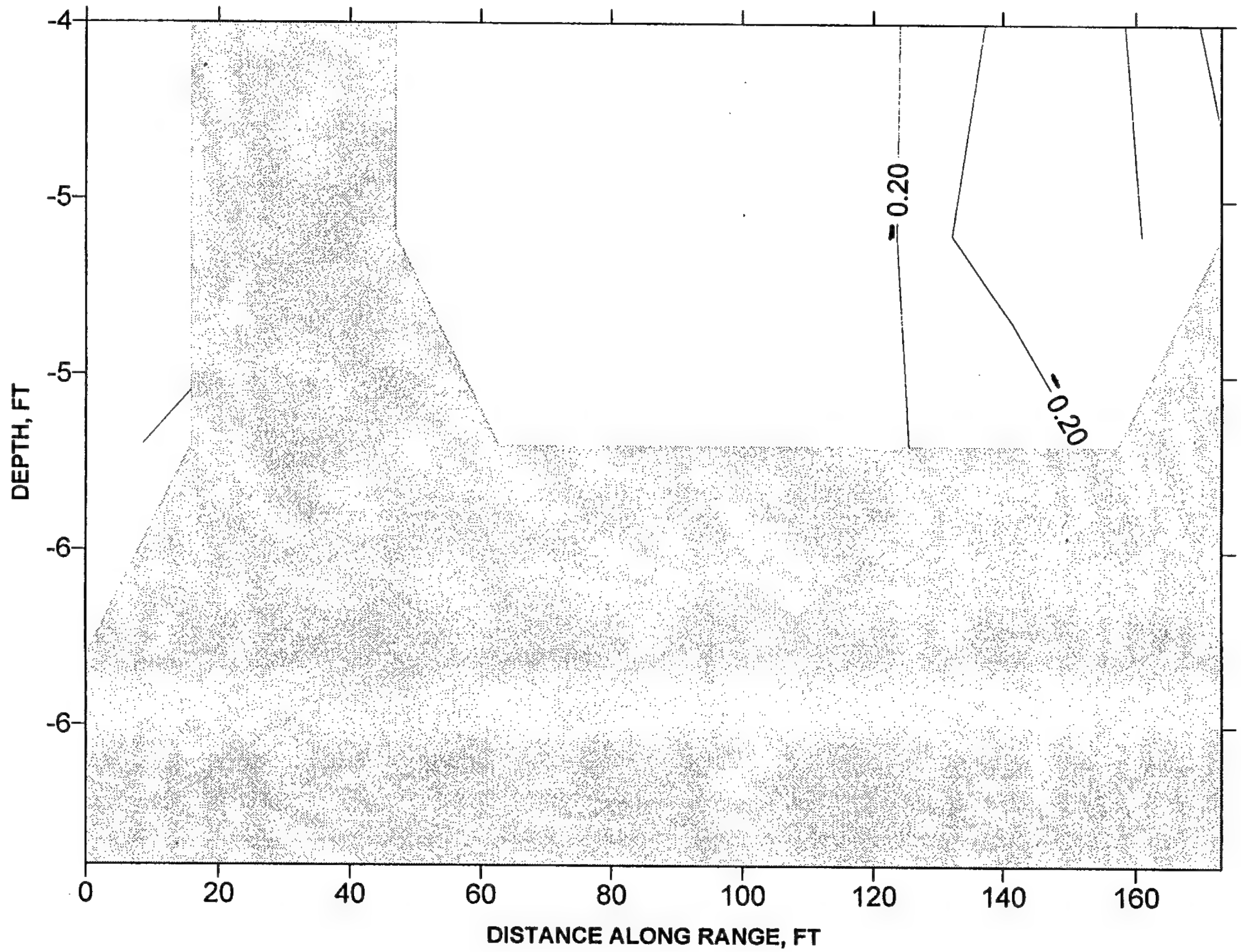
Plate 42



VELOCITY MAGNITUDES, FPS
Range 3 1353
17 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 3 1633
17 AUGUST 1995



VELOCITY MAGNITUDES, FPS
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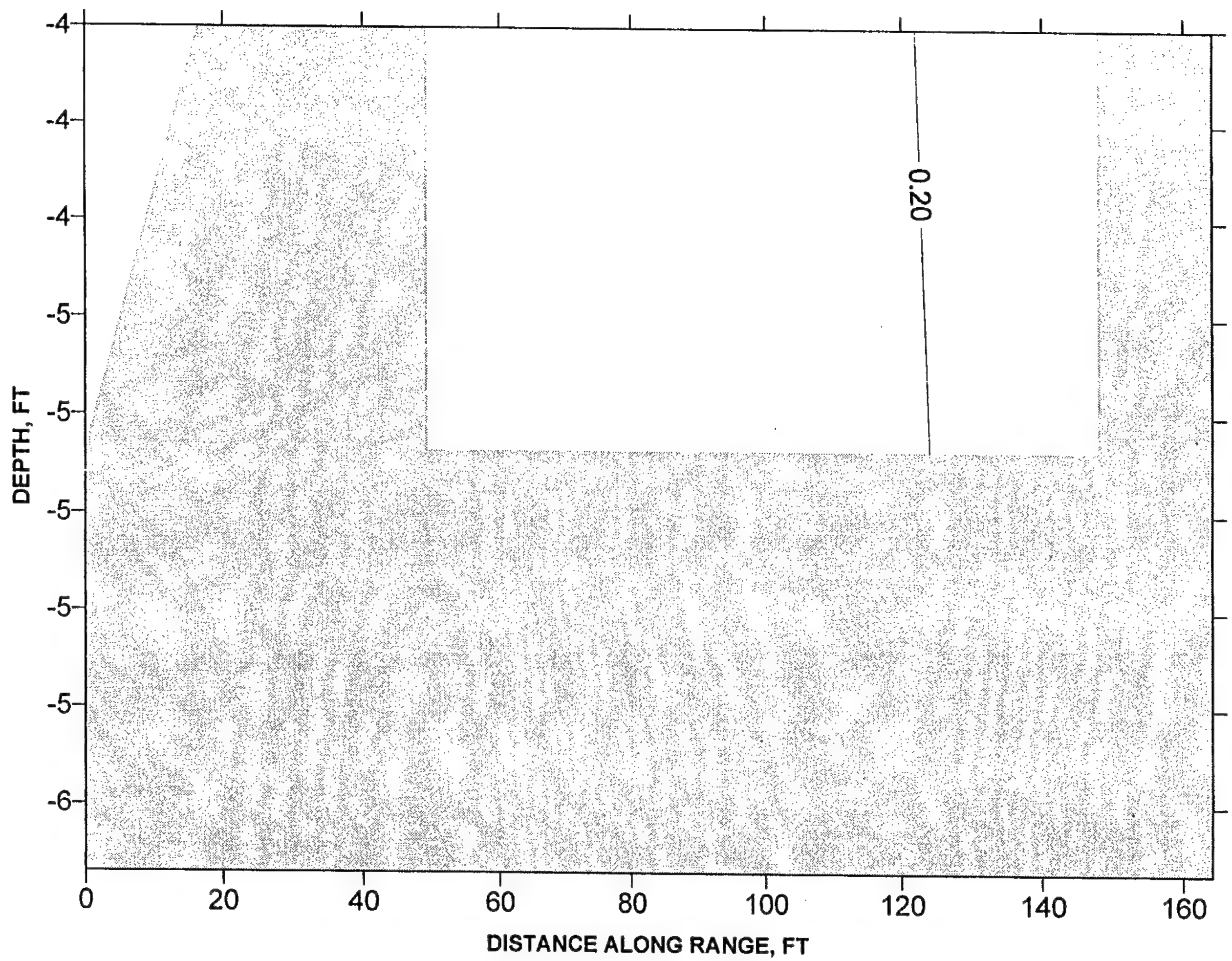
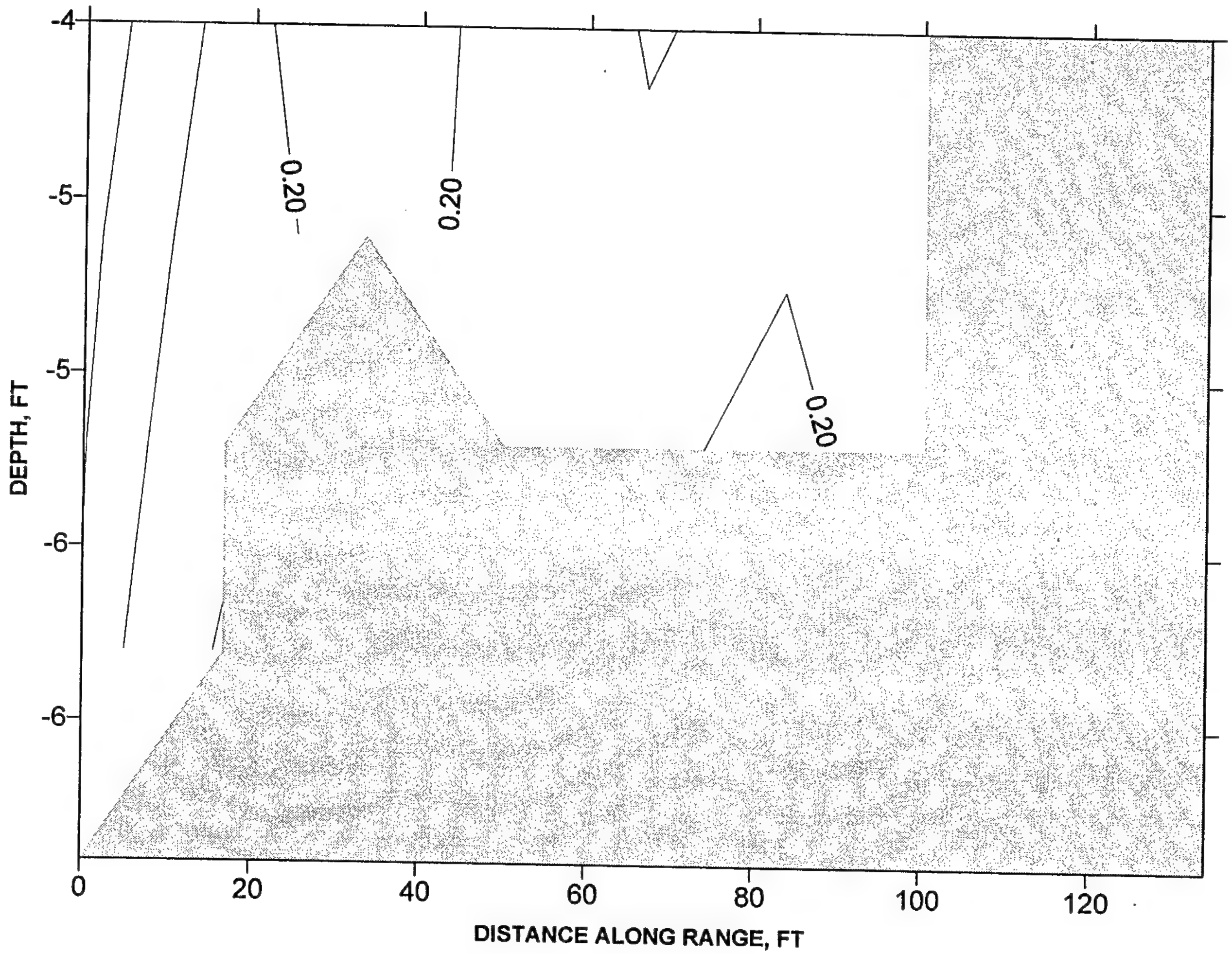
17 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 4 0815
17 AUGUST 1995



VELOCITY MAGNITUDES, FPS
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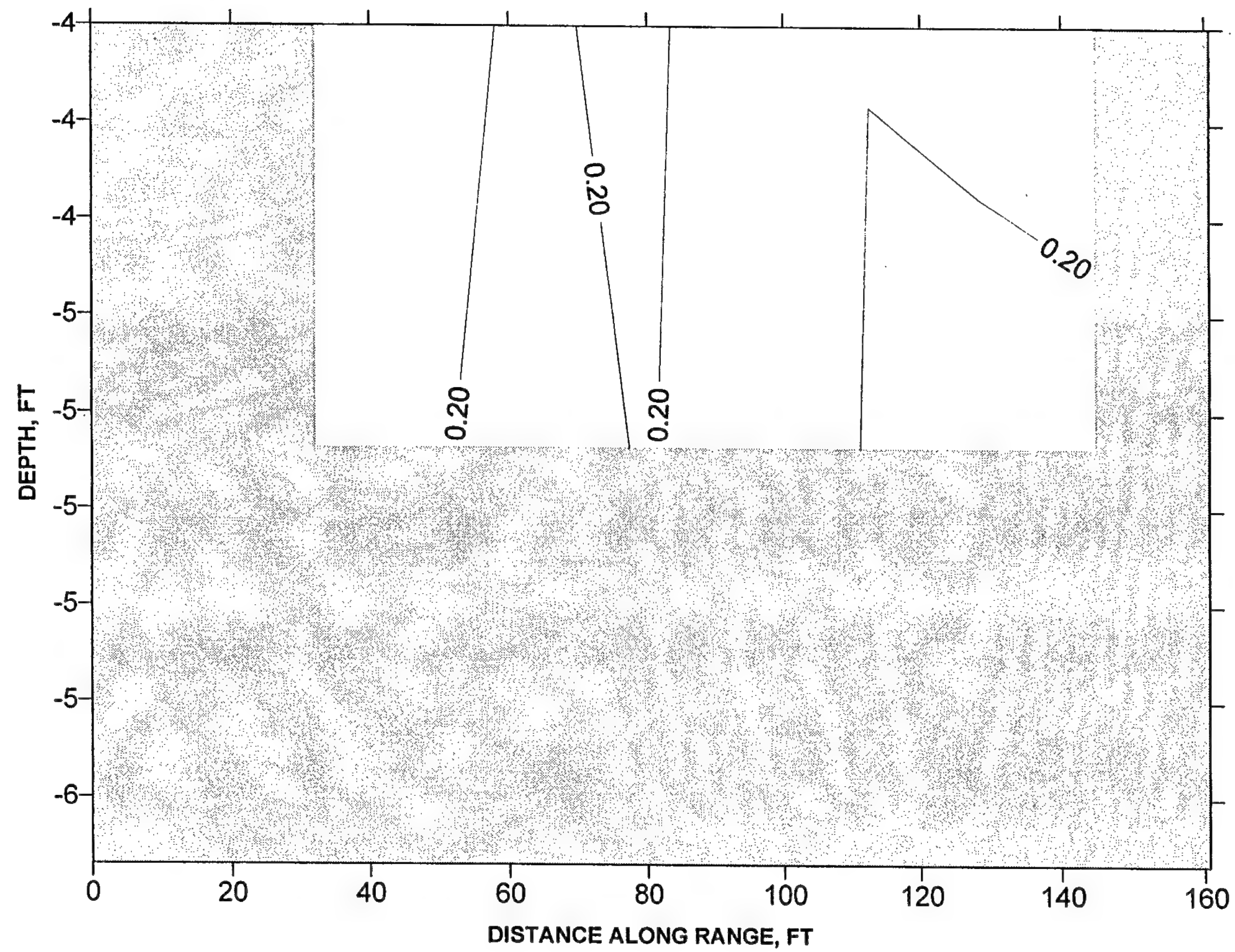
17 AUGUST 1995



VELOCITY MAGNITUDES, FPS
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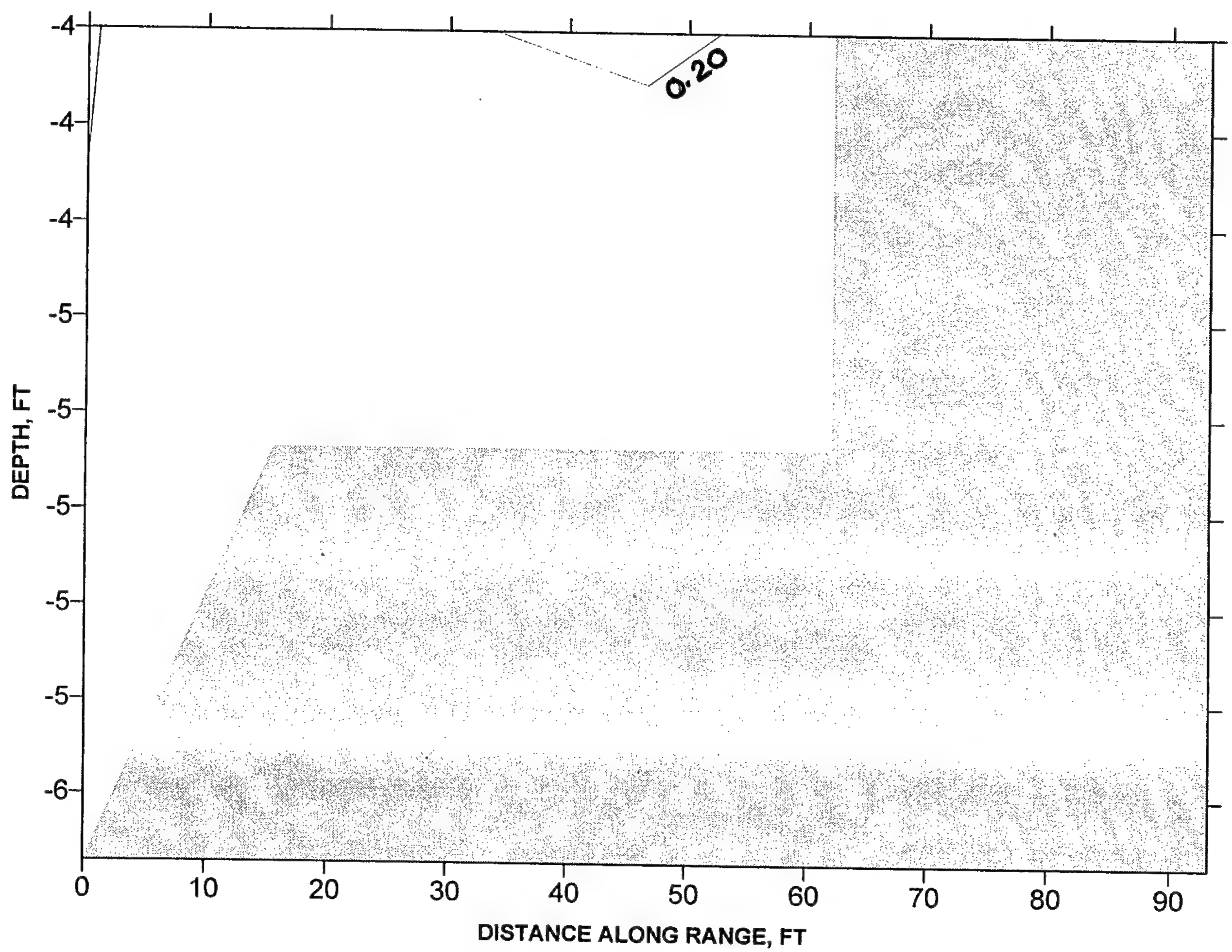
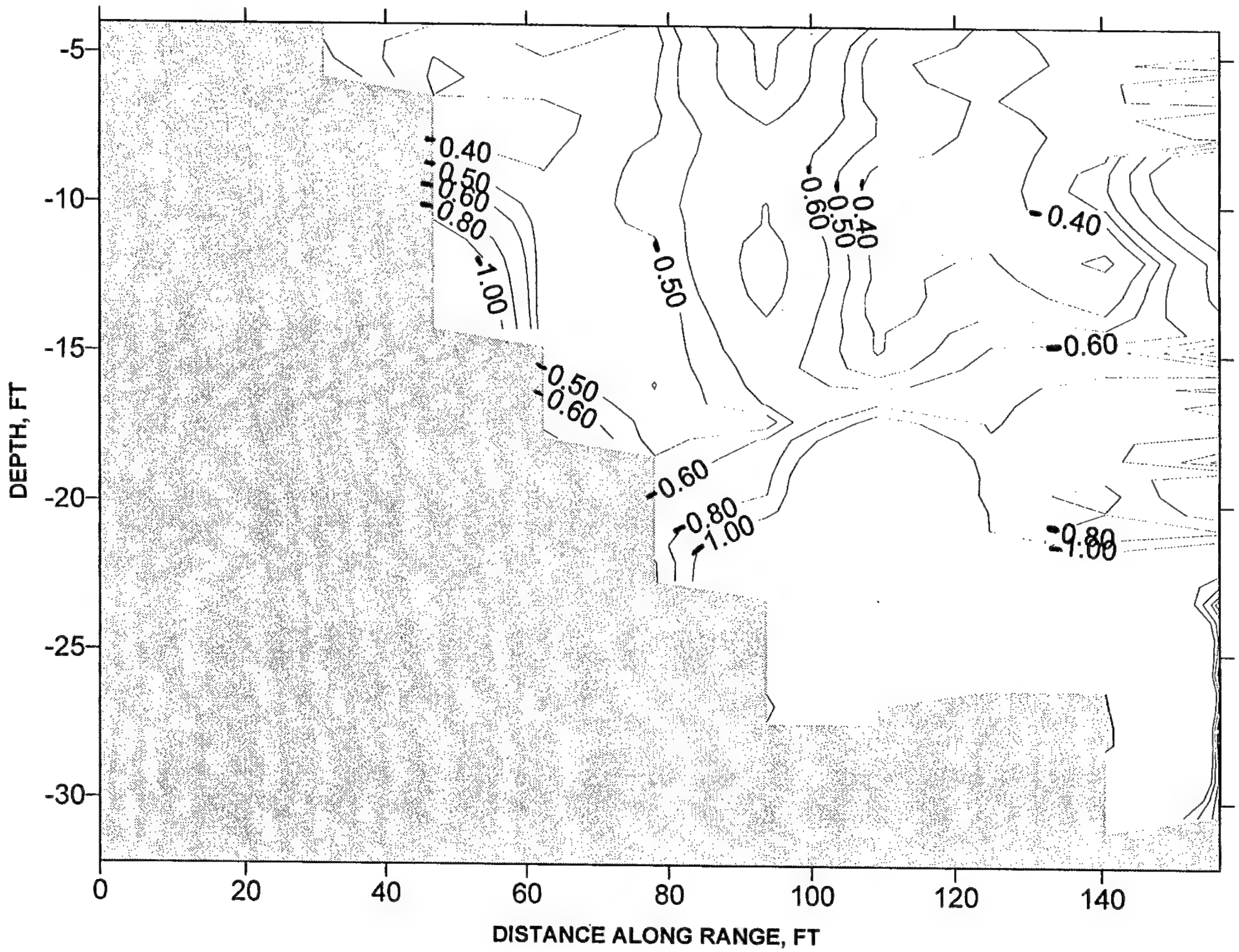
17 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 4 1215
17 AUGUST 1995



VELOCITY MAGNITUDES, FPS
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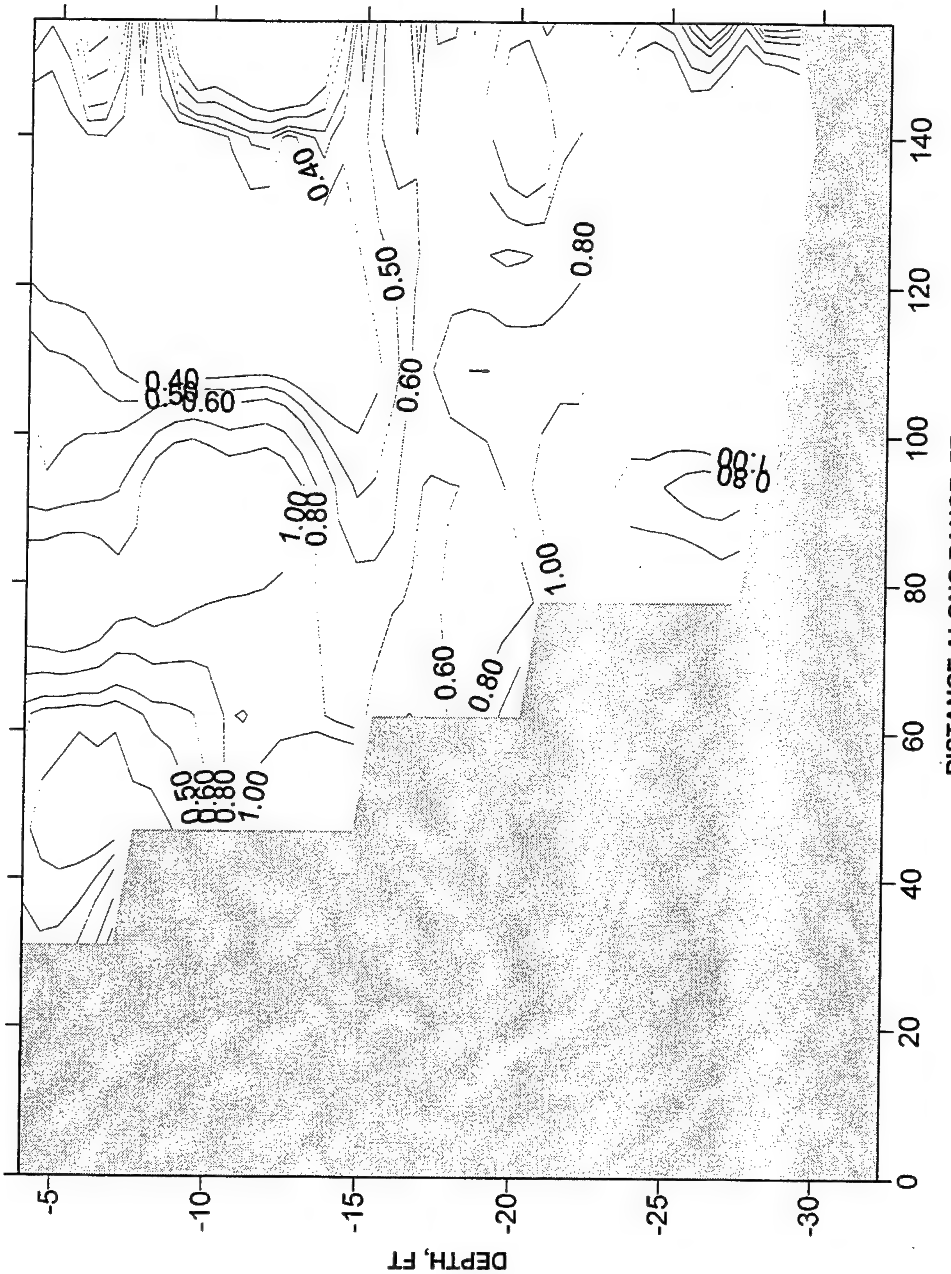
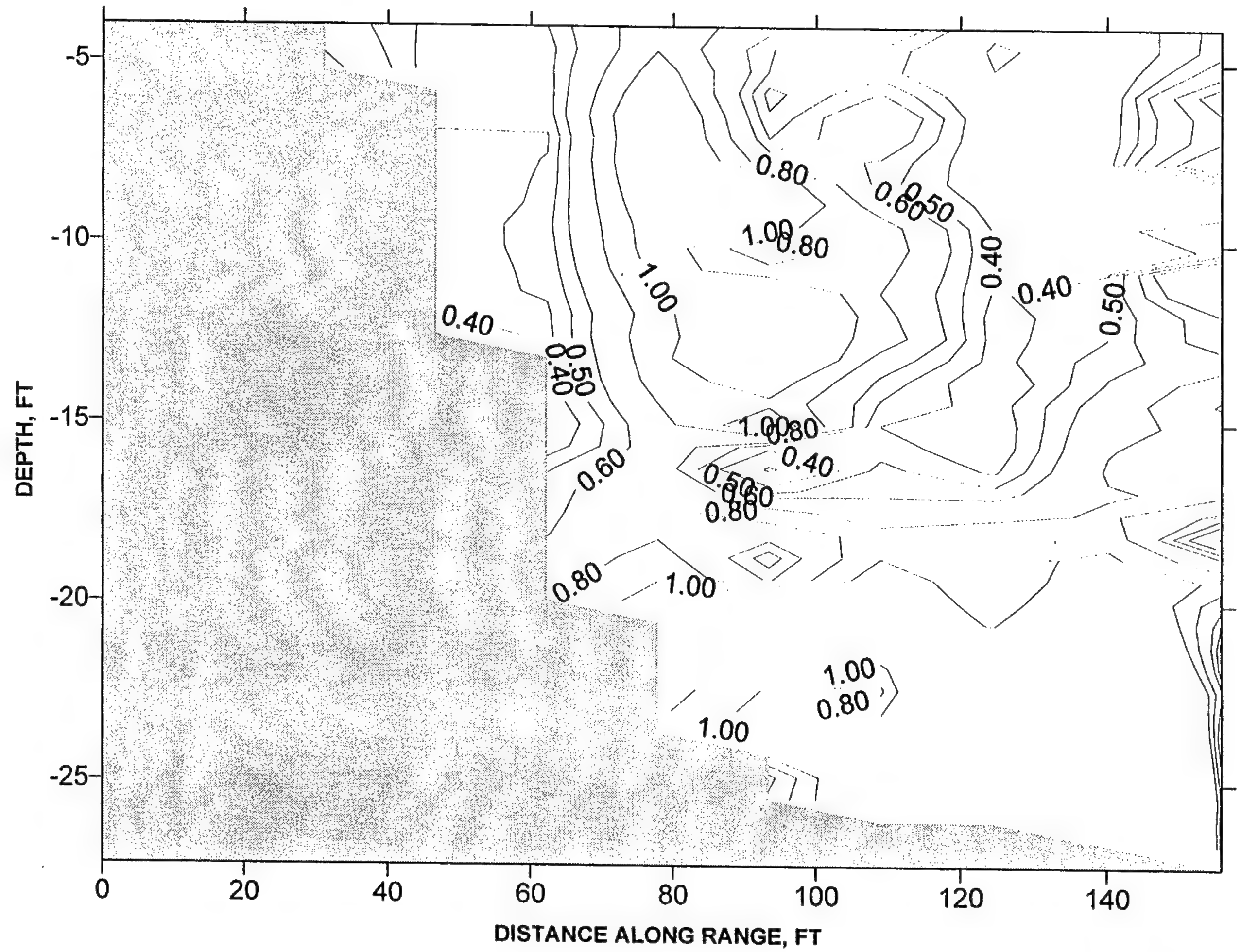
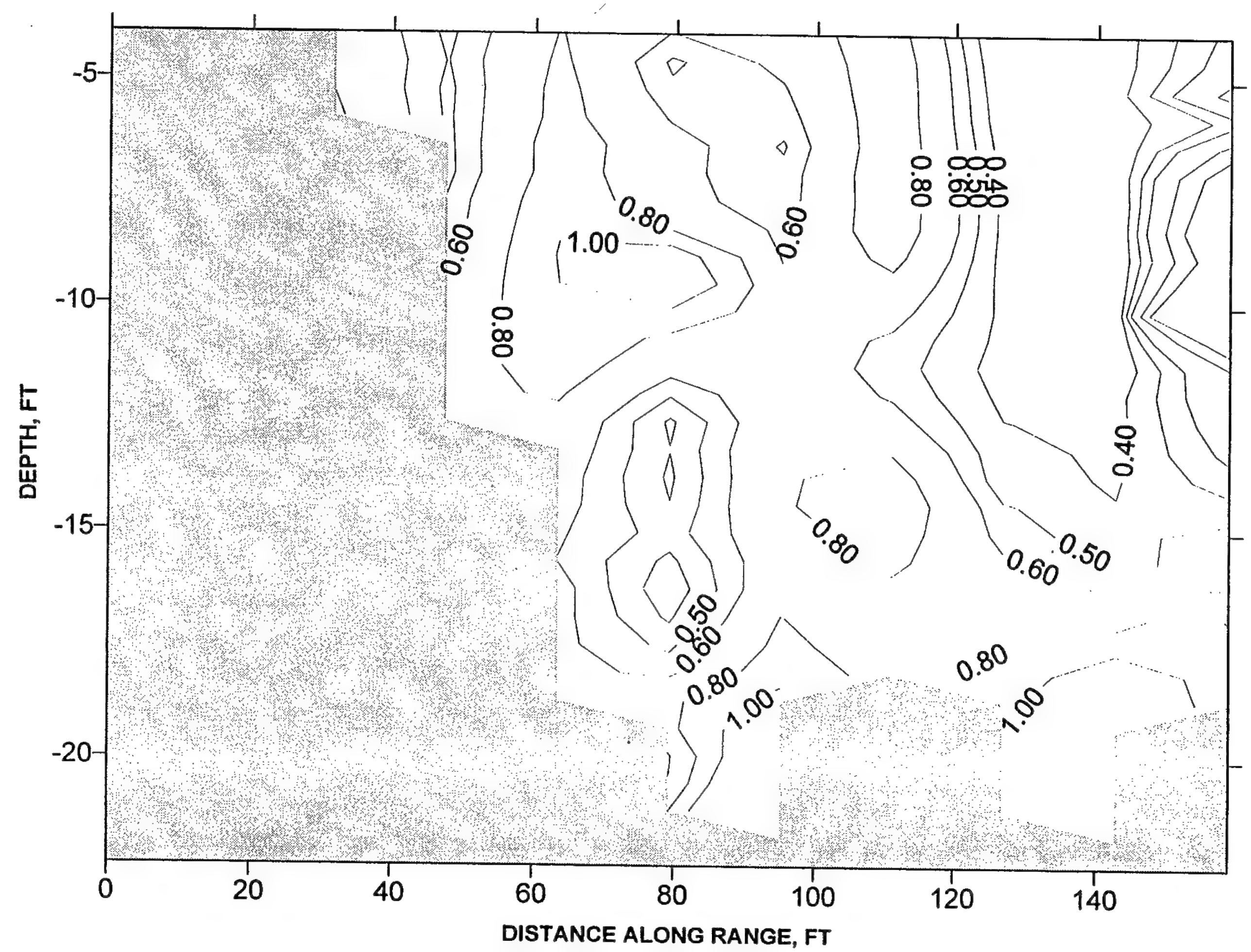
17 AUGUST 1995



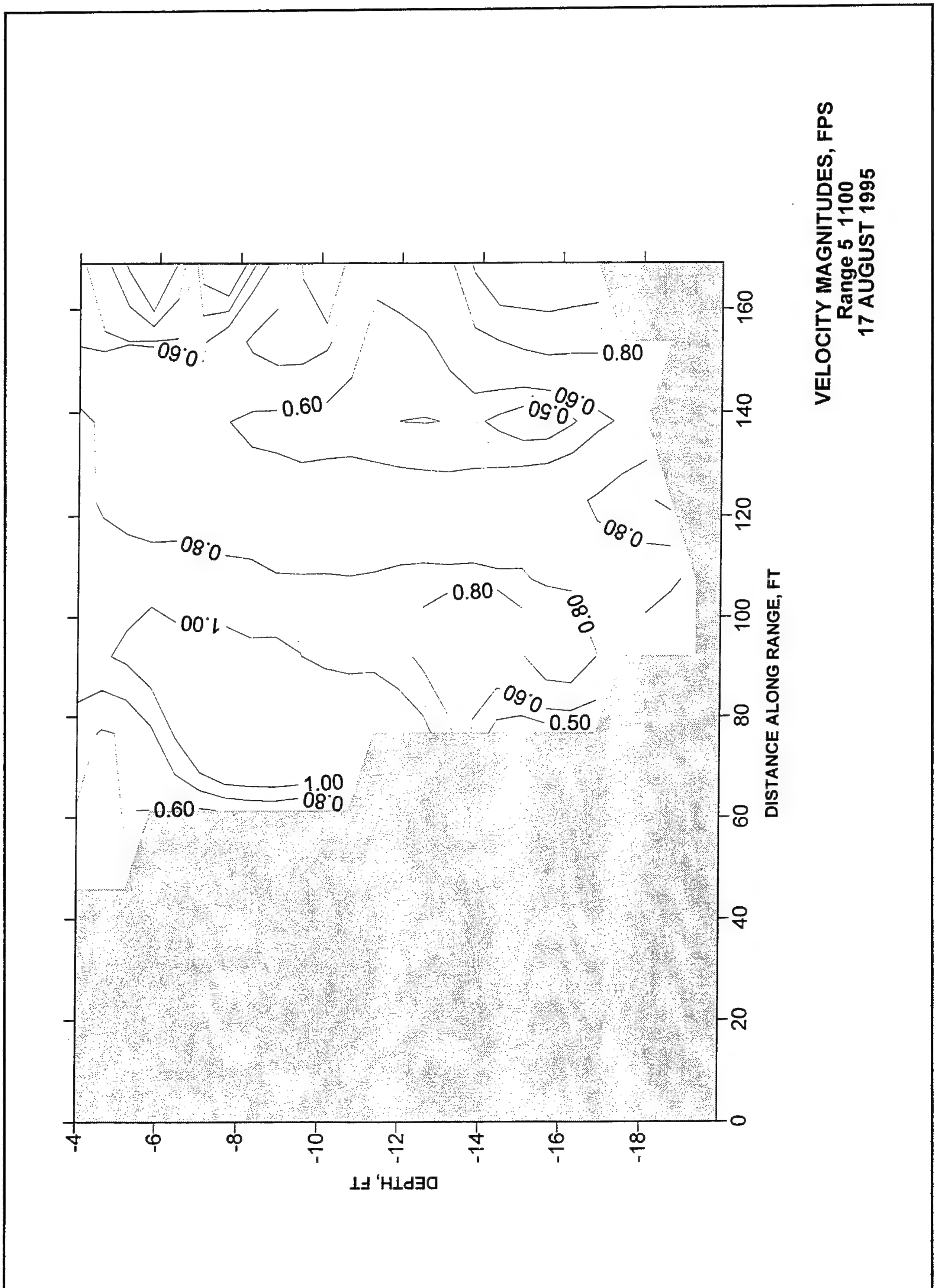
VELOCITY MAGNITUDES, FPS
Range 5 0735
17 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 5 0835
17 AUGUST 1995

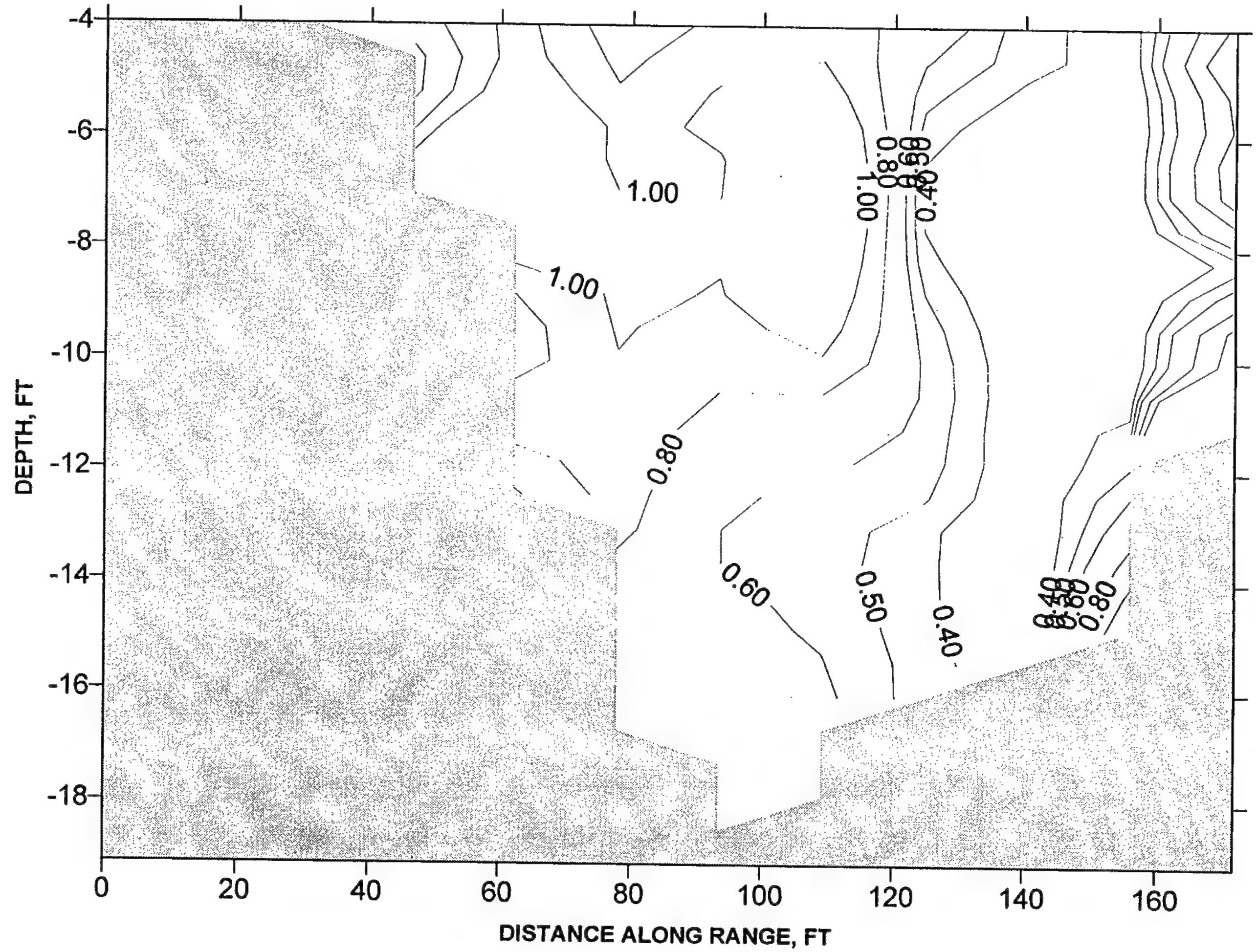


VELOCITY MAGNITUDES, FPS
Range 5 0950
17 AUGUST 1995

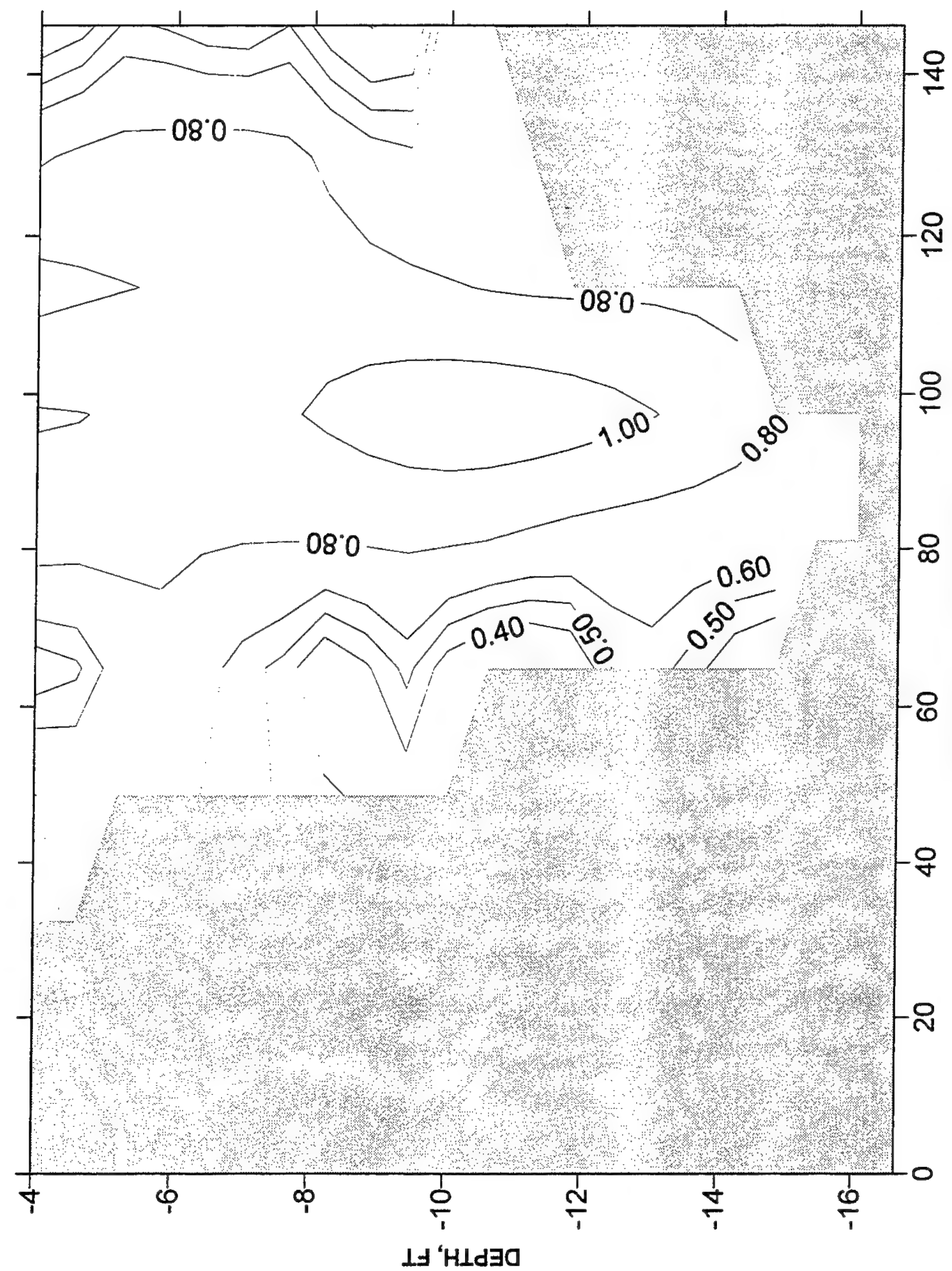


VELOCITY MAGNITUDES, FPS
Range 5 1100
17 AUGUST 1995
DISTANCE ALONG RANGE, FT
DEPTH, FT
0
20
40
60
80
100
120
140
160
-4
-6
-8
-10
-12
-14
-16
-18
0.60
0.80
1.00
0.50

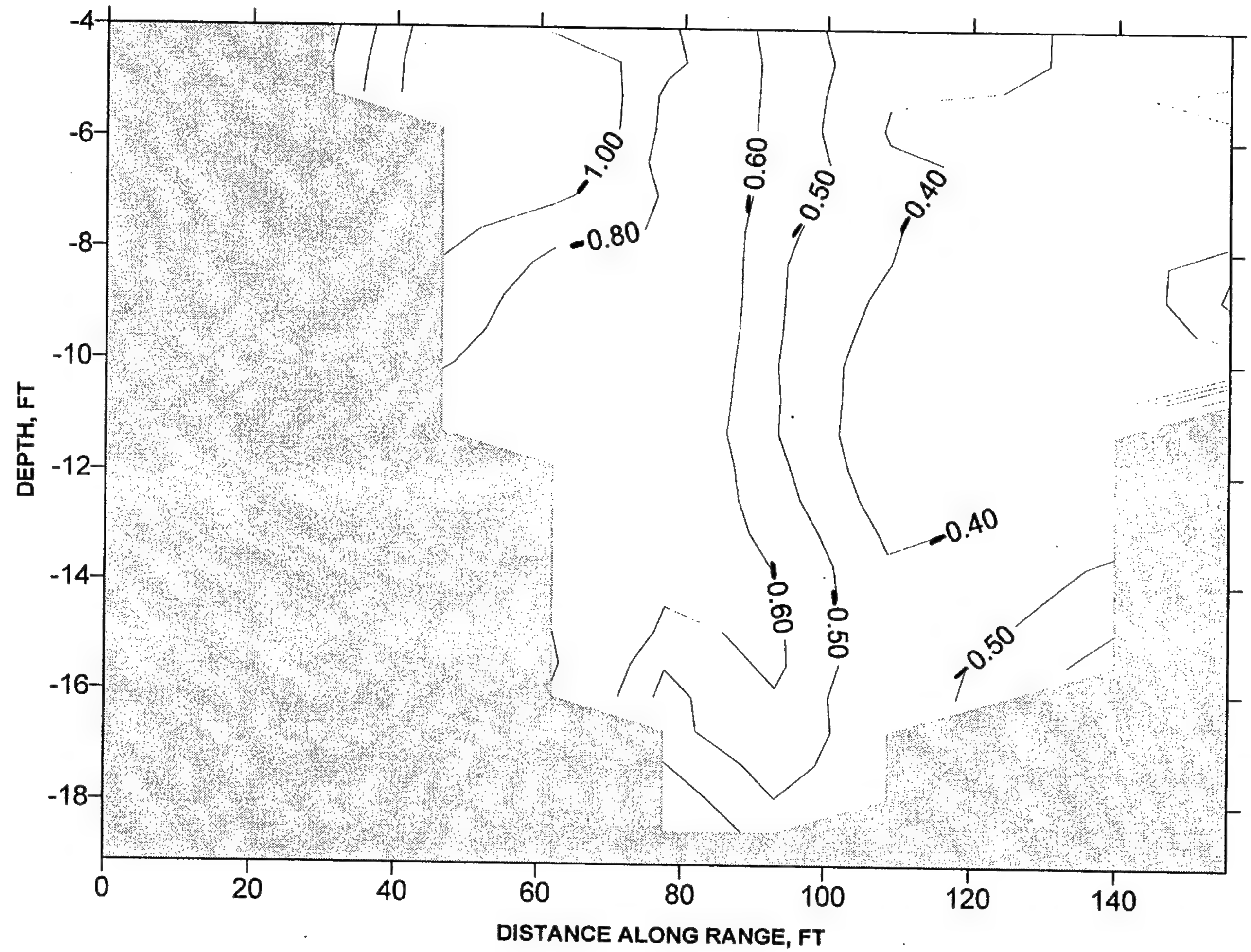
Plate 54



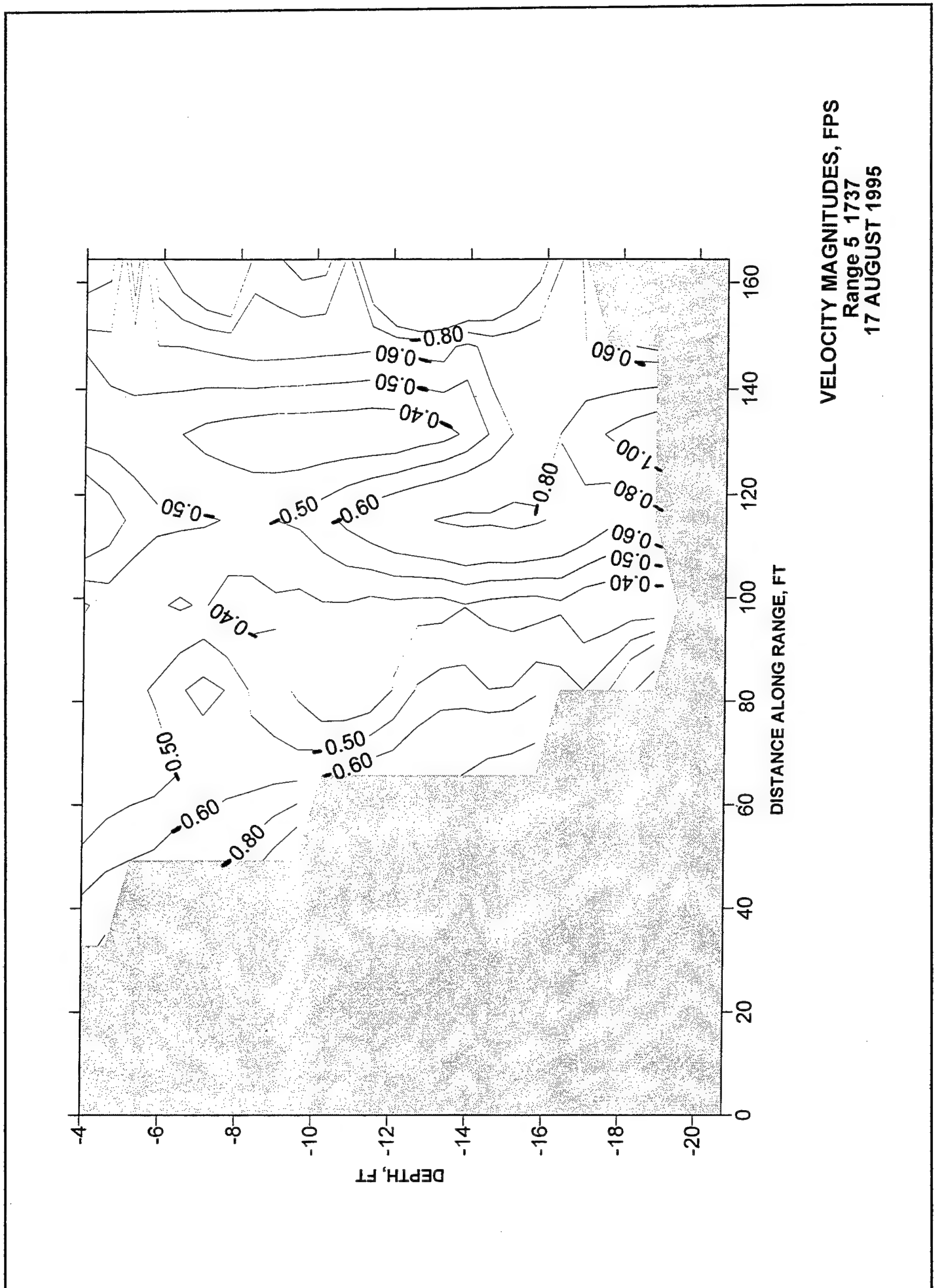
VELOCITY MAGNITUDES, FPS
Range 5 1230
17 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 5 1350
17 AUGUST 1995

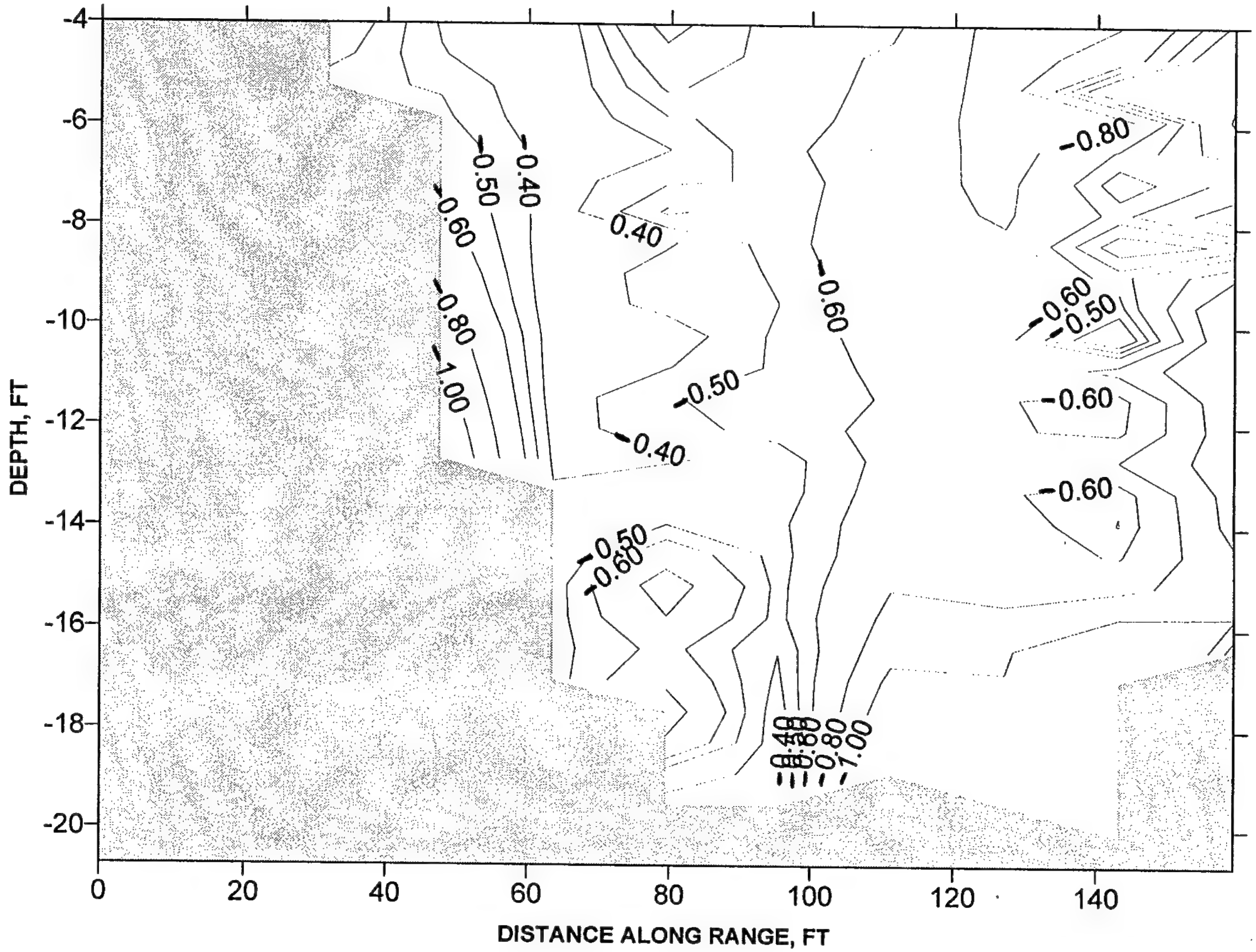


VELOCITY MAGNITUDES, FPS
Range 5 1542
17 AUGUST 1995

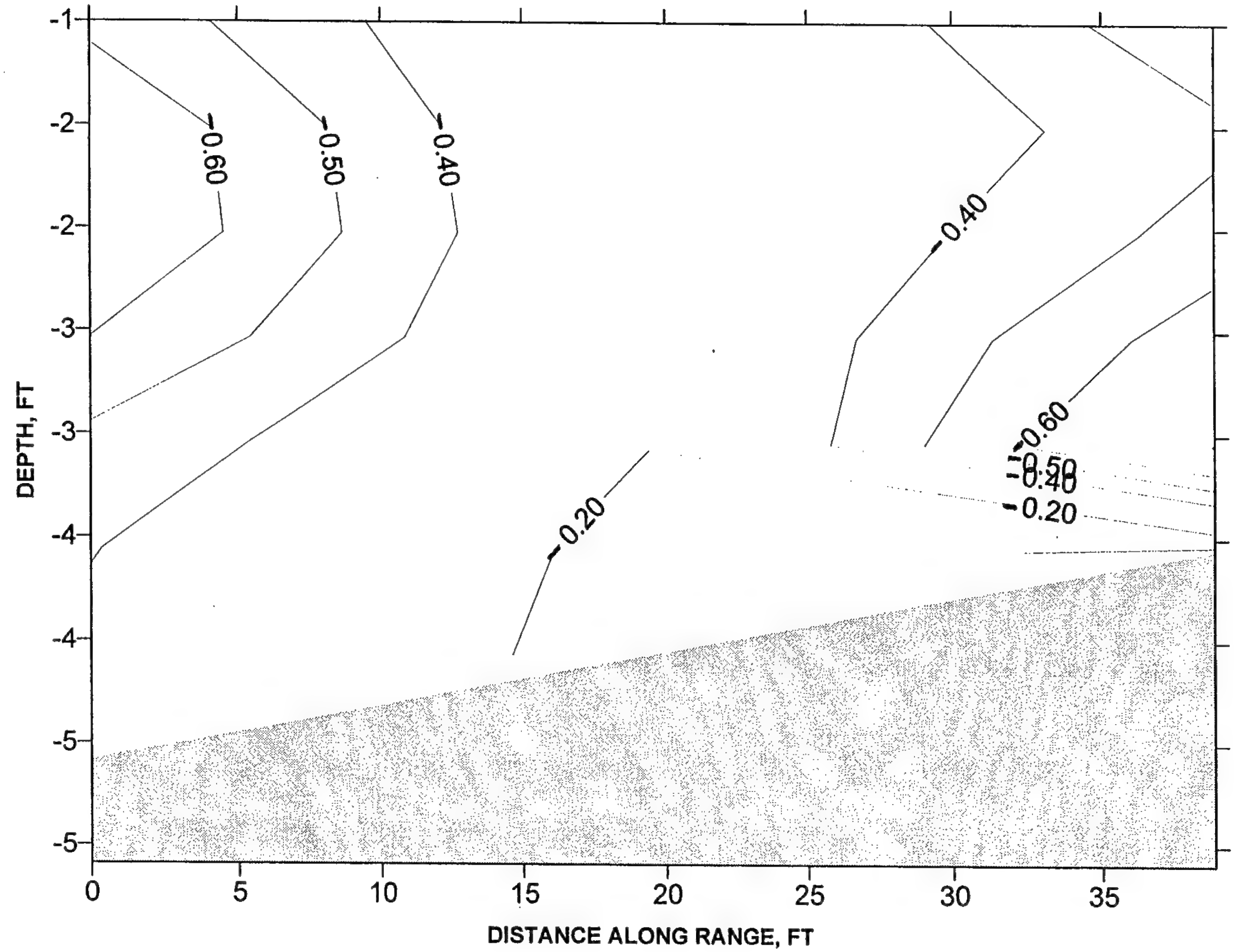


VELOCITY MAGNITUDES, FPS
Range 5 1737
17 AUGUST 1995
DISTANCE ALONG RANGE, FT
DEPTH, FT
0.40
0.50
0.60
0.80
1.00

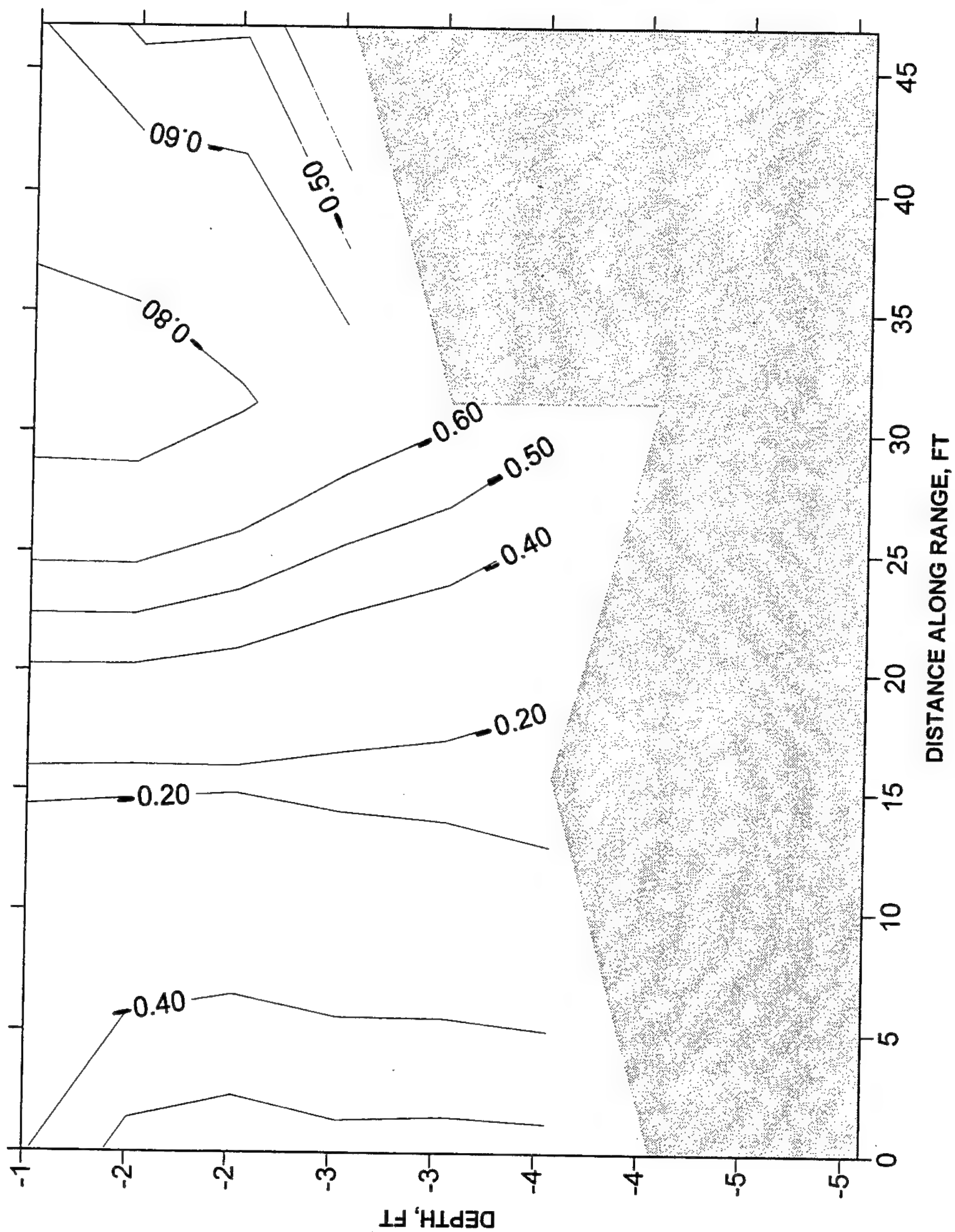
Plate 58



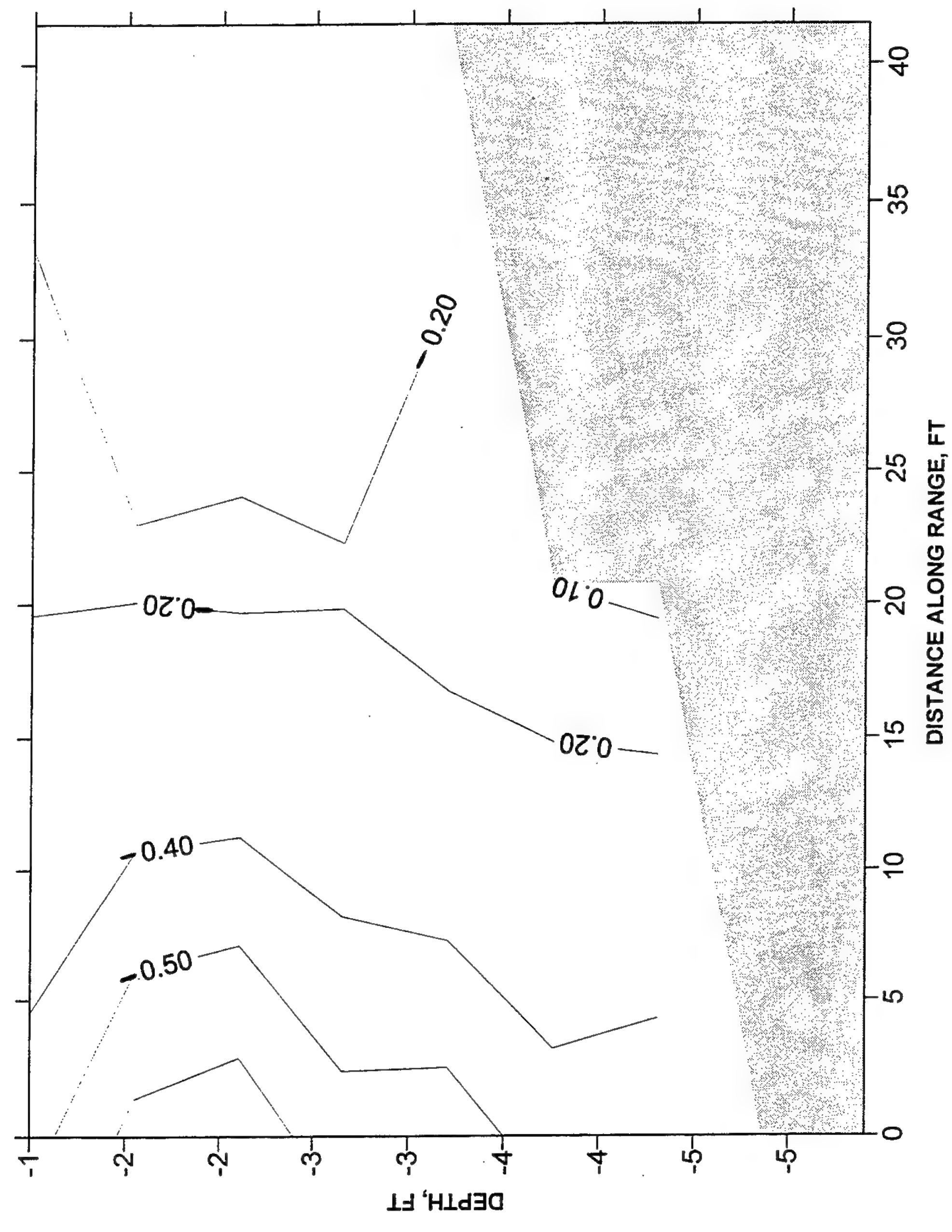
VELOCITY MAGNITUDES, FPS
Range 5 1830
17 AUGUST 1995



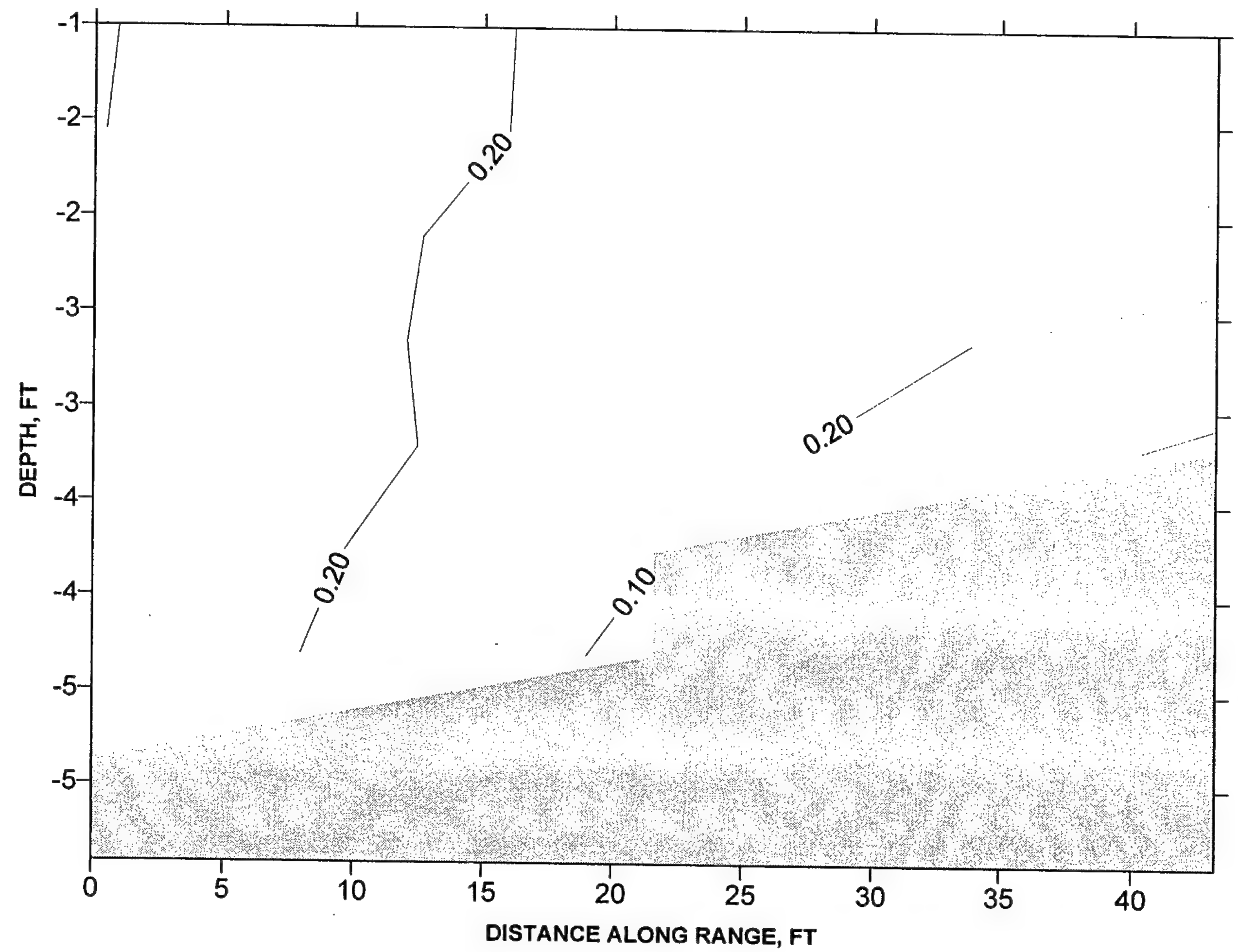
VELOCITY MAGNITUDES, FPS
Range 6 0650
17 AUGUST 1995



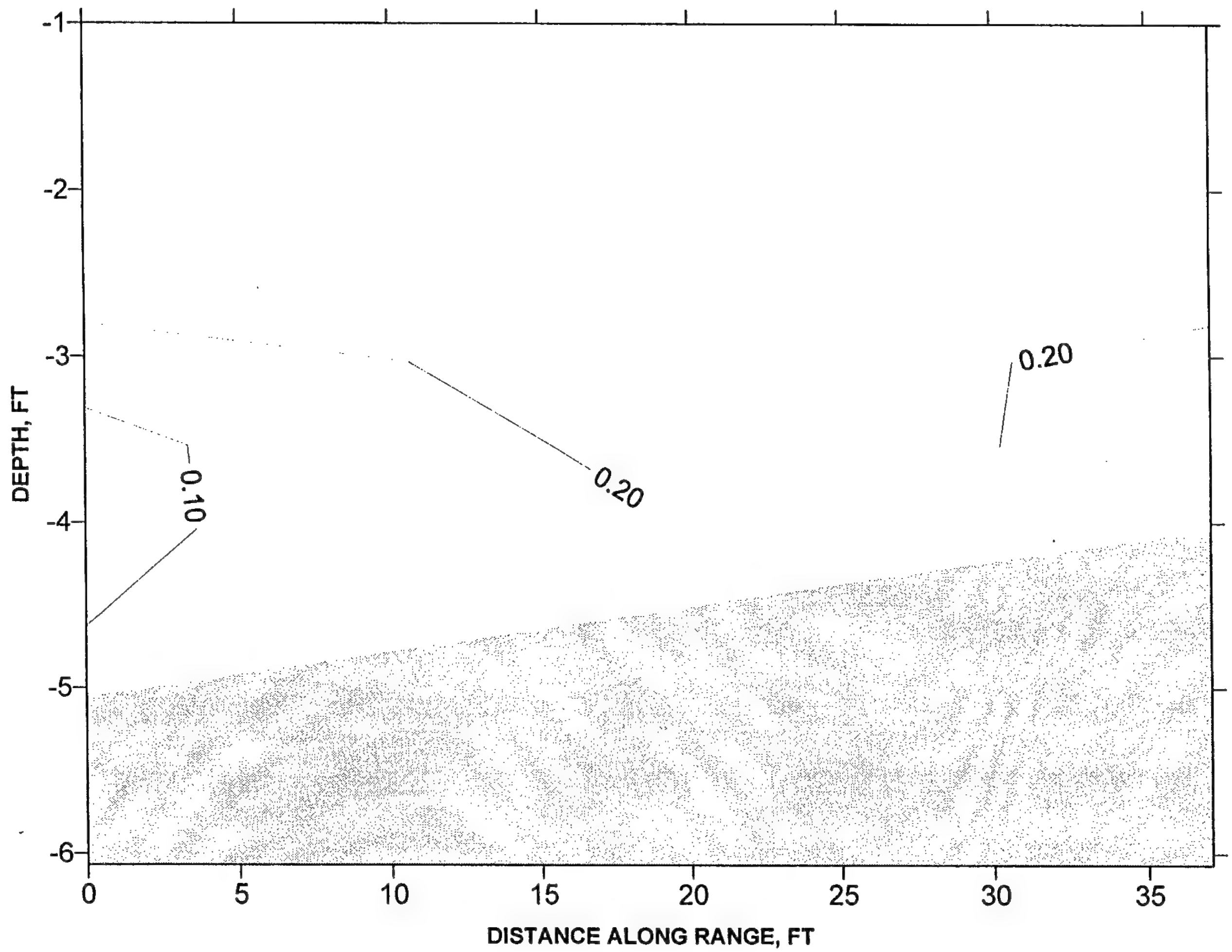
VELOCITY MAGNITUDES, FPS
Range 6 0750
17 AUGUST 1995



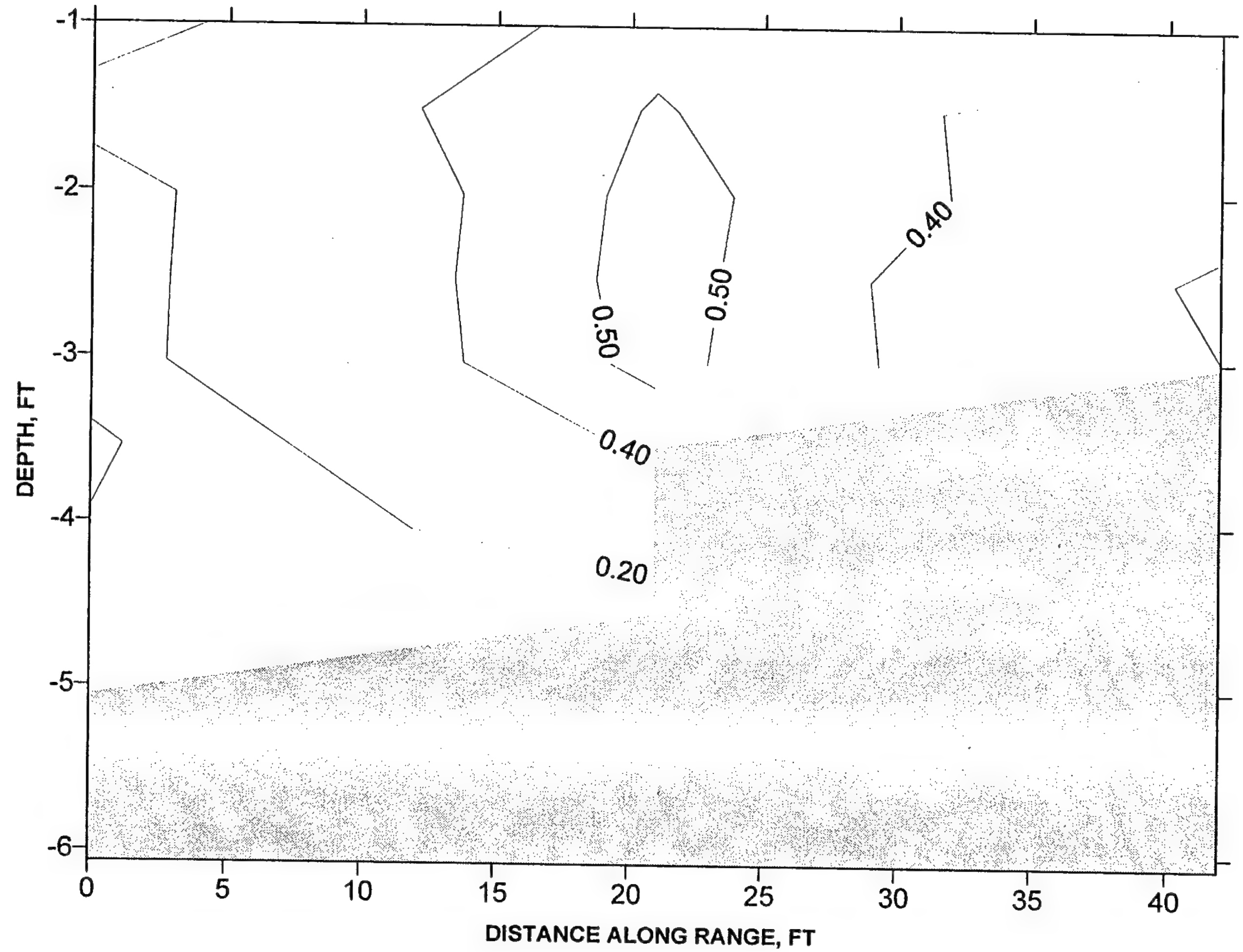
VELOCITY MAGNITUDES, FPS
Range 6 0850
17 AUGUST 1995



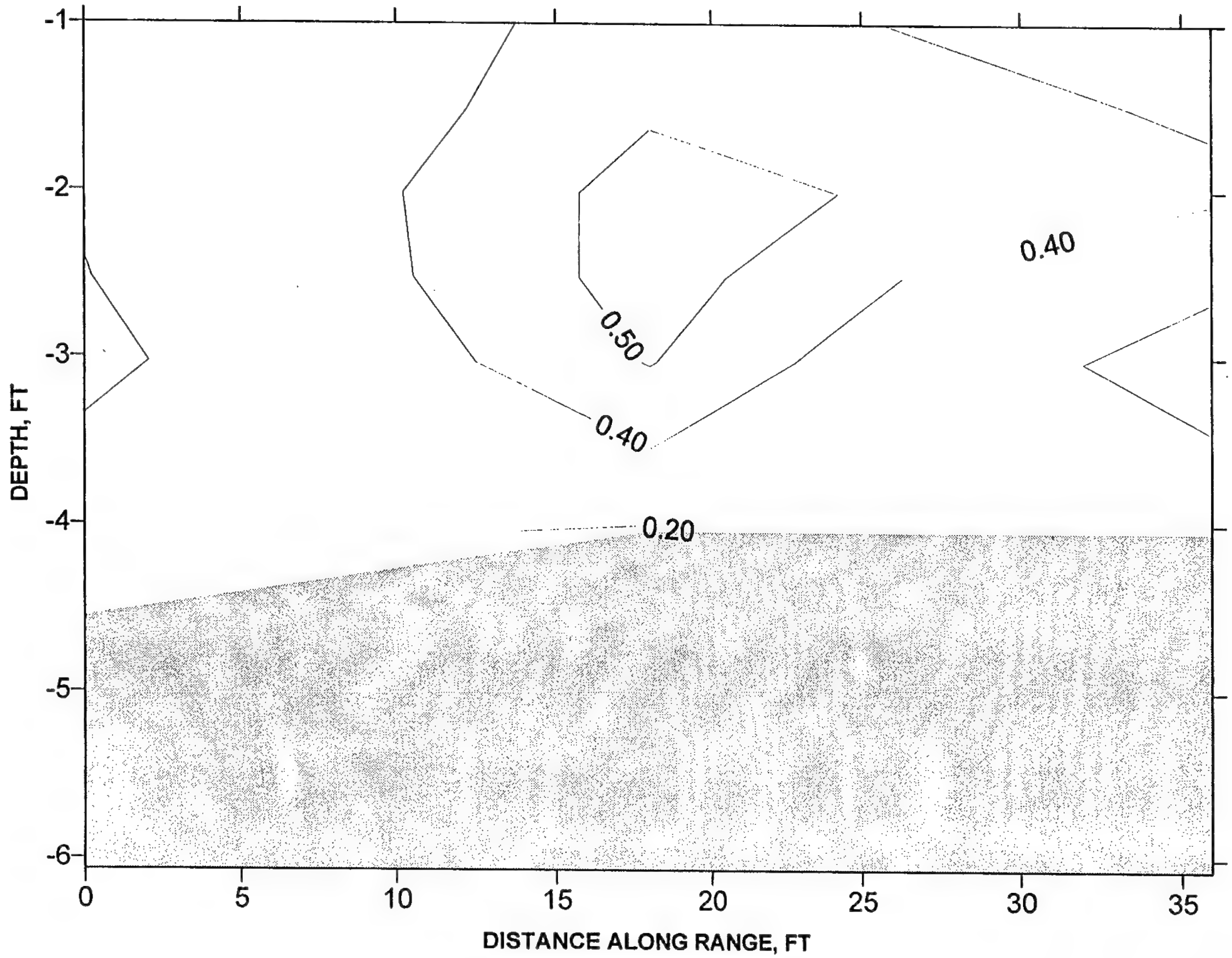
VELOCITY MAGNITUDES, FPS
Range 6 1005
17 AUGUST 1995



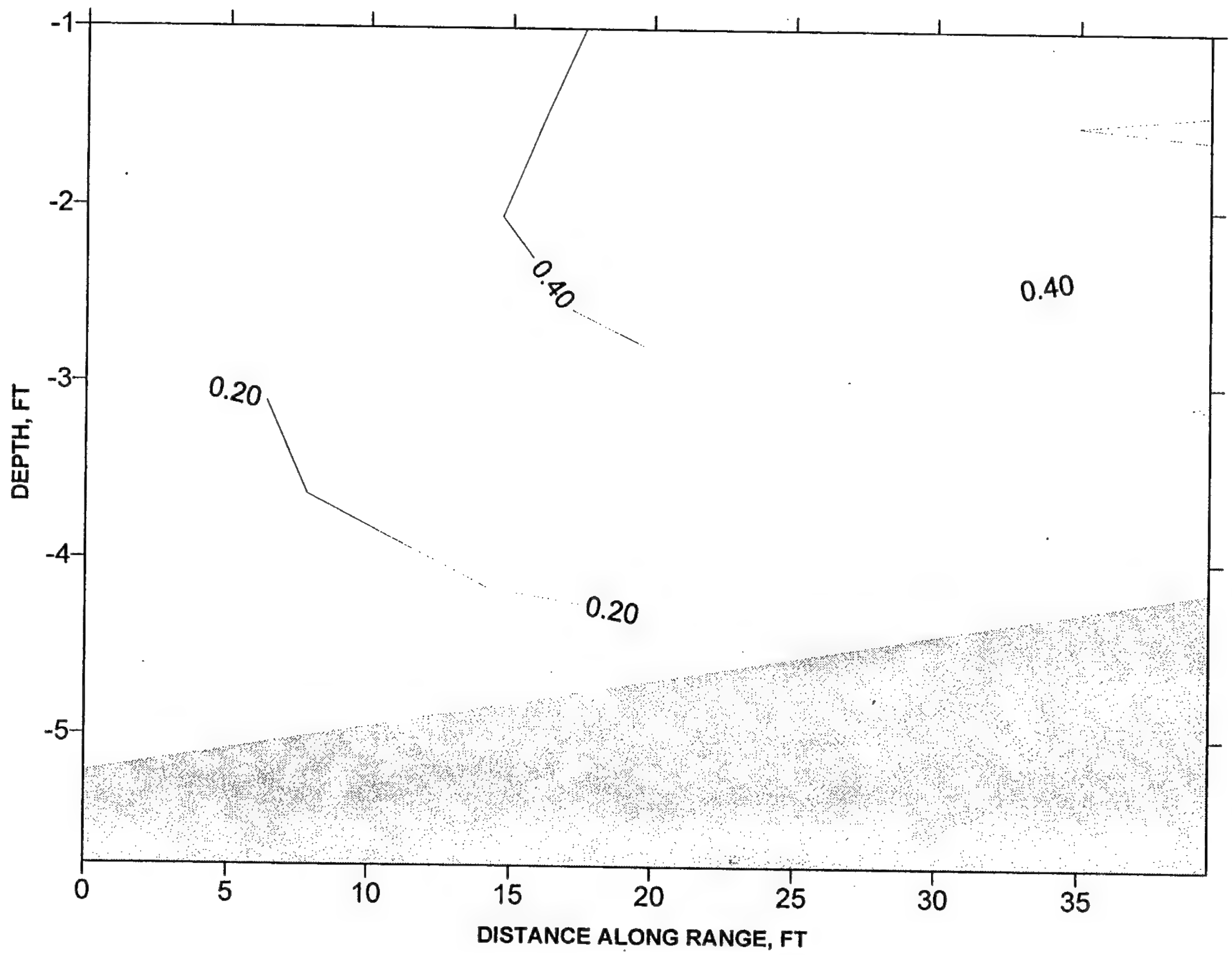
VELOCITY MAGNITUDES, FPS
Range 6 1115
17 AUGUST 1995



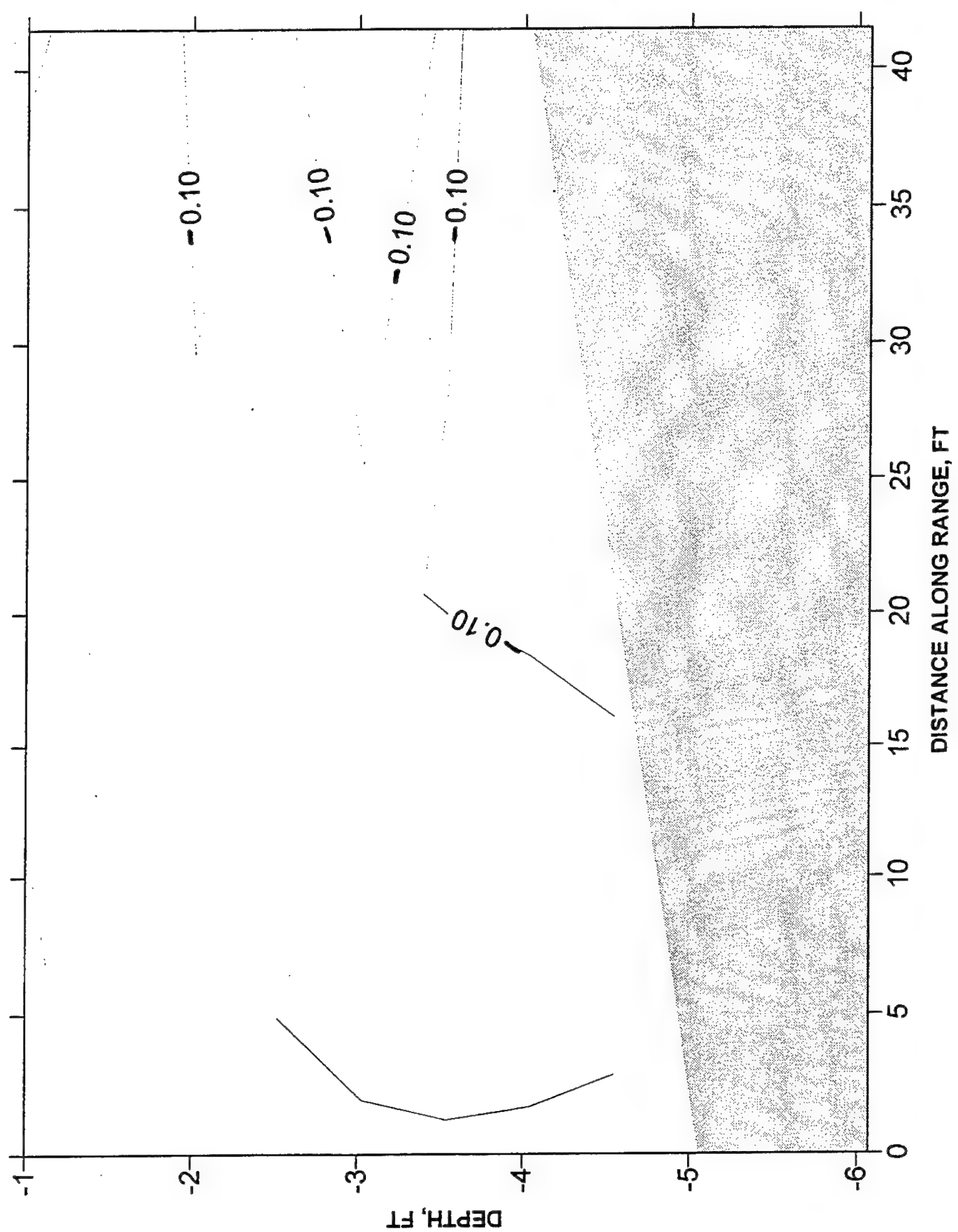
VELOCITY MAGNITUDES, FPS
Range 6 1307
17 AUGUST 1995



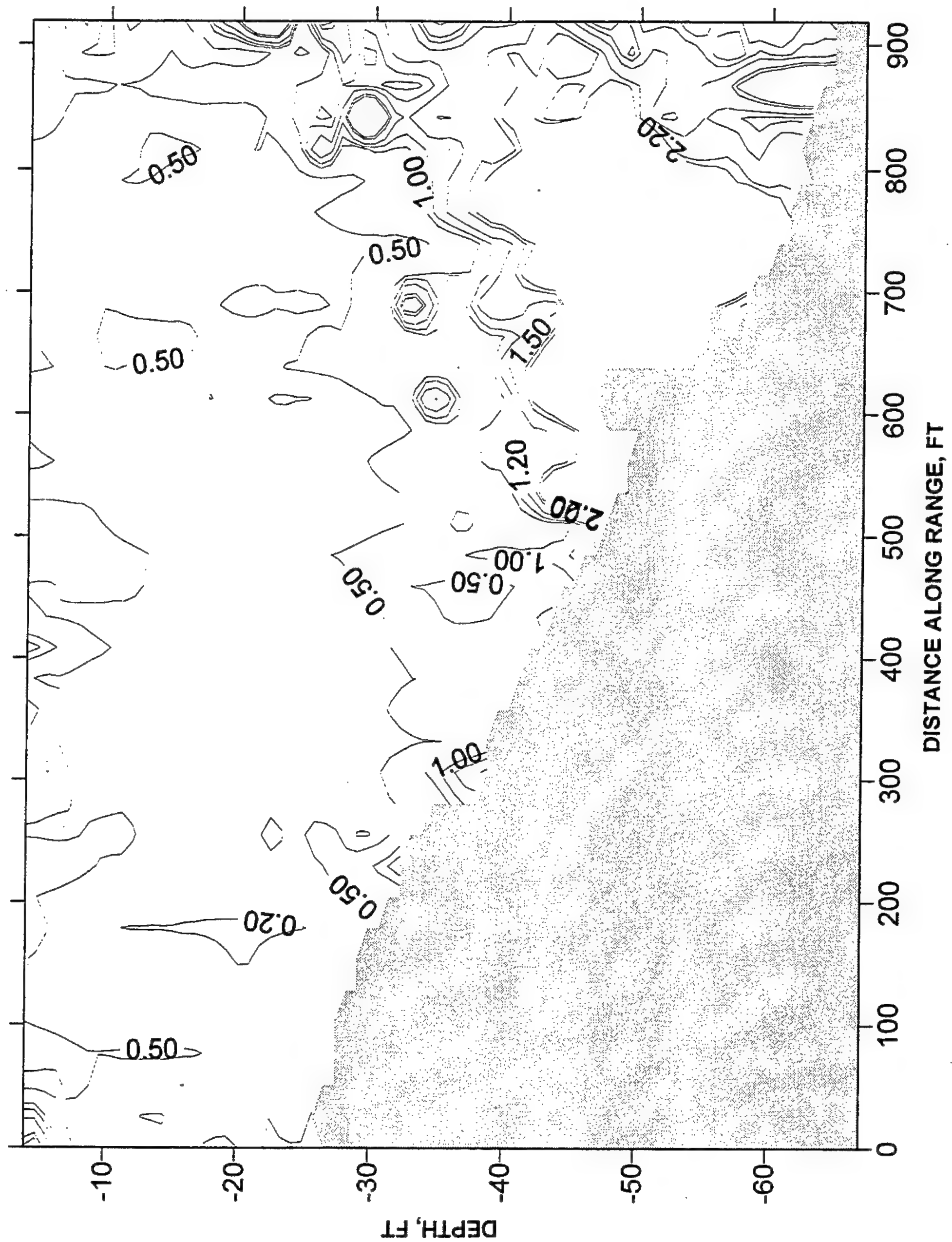
VELOCITY MAGNITUDES, FPS
Range 6 1407
17 AUGUST 1995



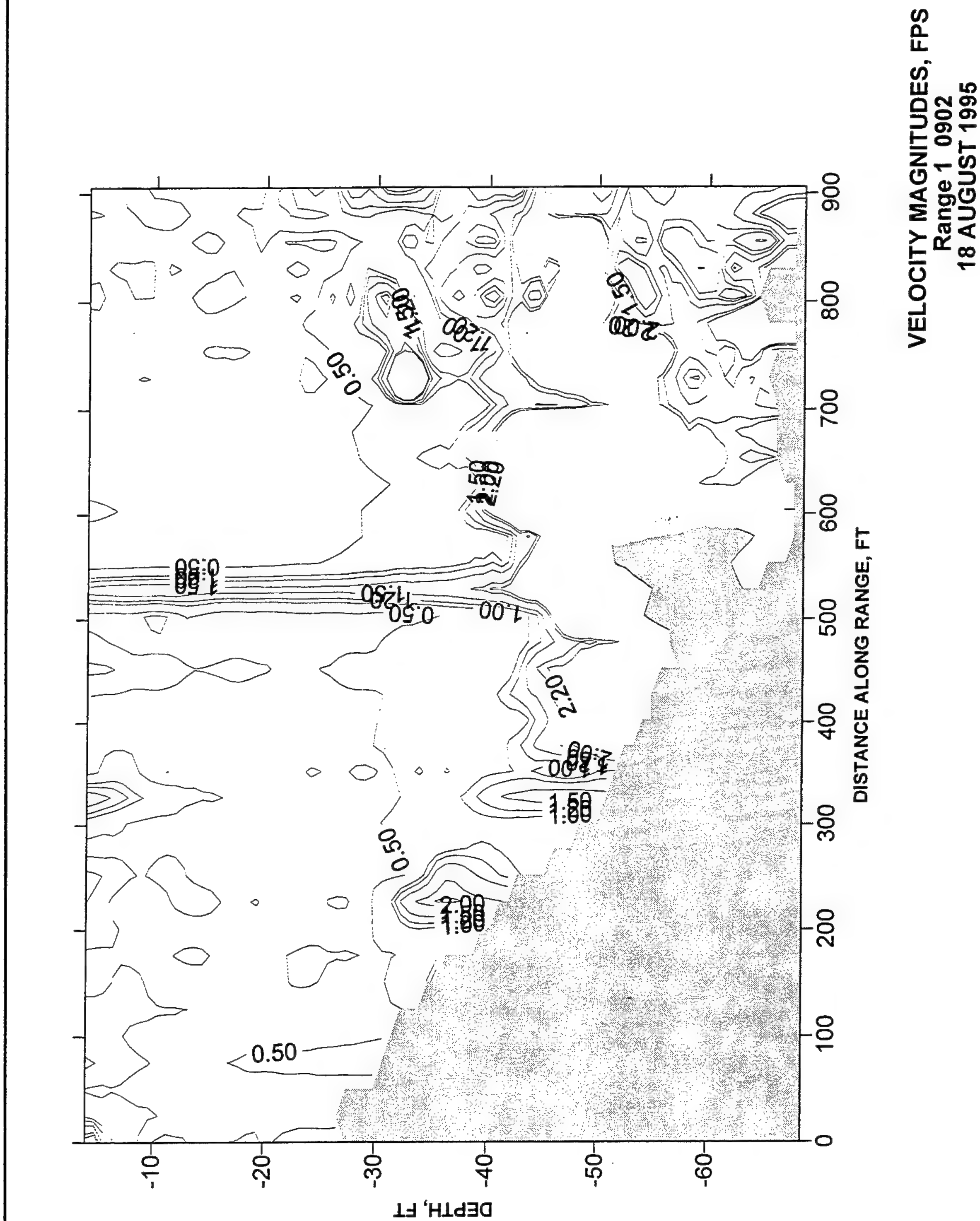
VELOCITY MAGNITUDES, FPS
Range 6. 1600
17 AUGUST 1995

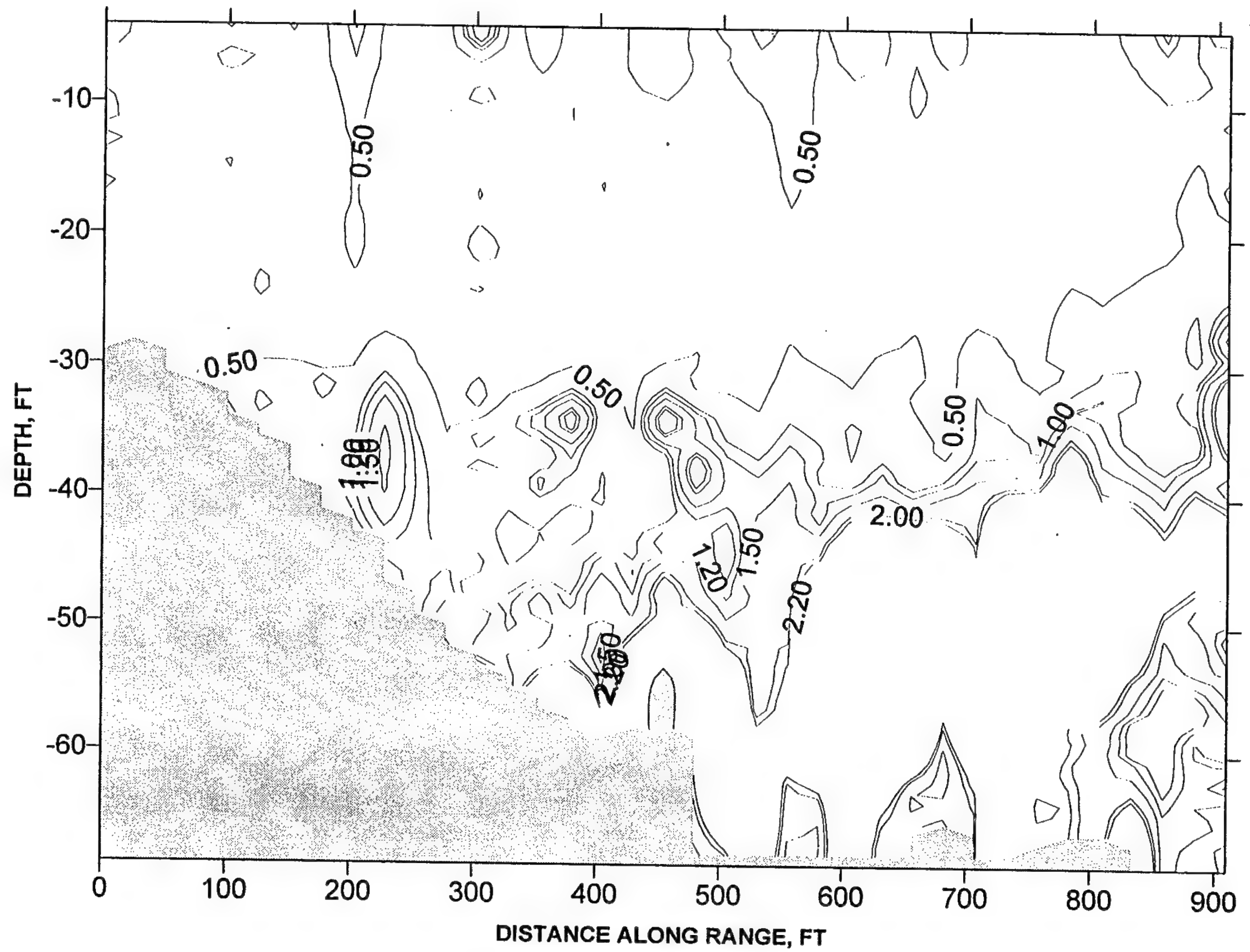


VELOCITY MAGNITUDES, FPS
Range 6 1755
17 AUGUST 1995

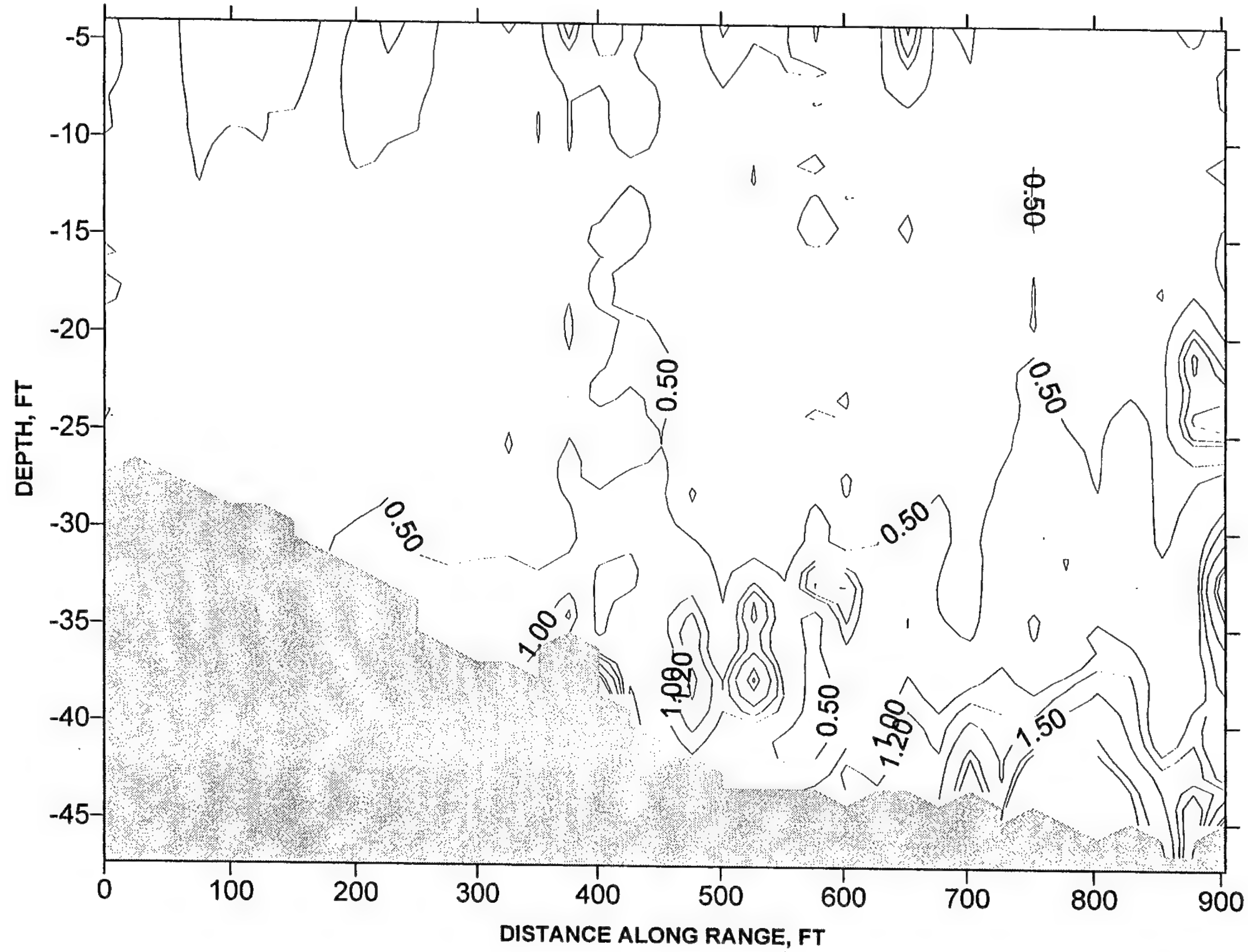


VELOCITY MAGNITUDES, FPS
Range 1 0738
18 AUGUST 1995

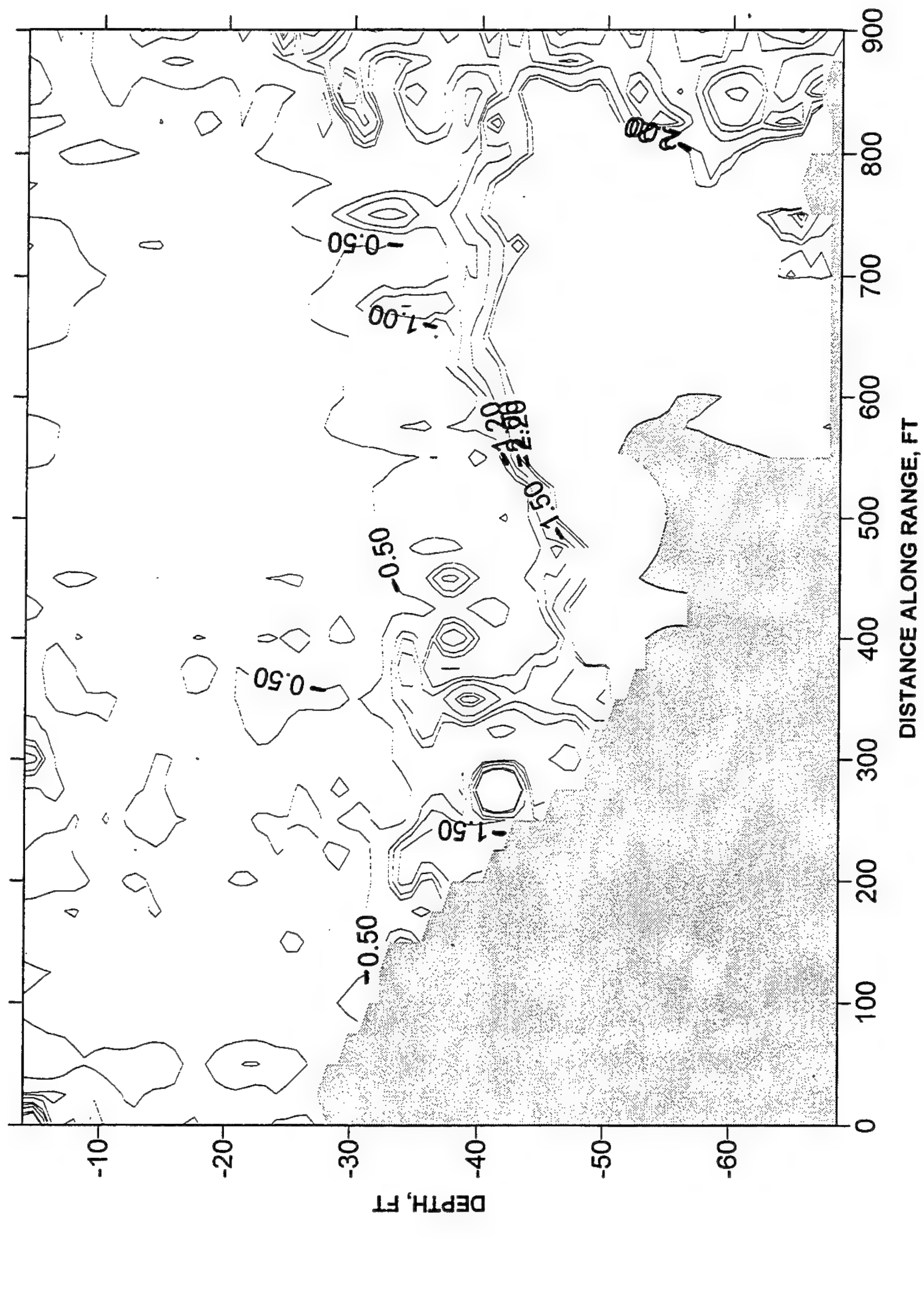

VELOCITY MAGNITUDES, FPS
Range 1 0902
18 AUGUST 1995
DISTANCE ALONG RANGE, FT
DEPTH, FT
0
100
200
300
400
500
600
700
800
900
-10
-20
-30
-40
-50
-60
0.50
1.00
1.50
2.00
2.20



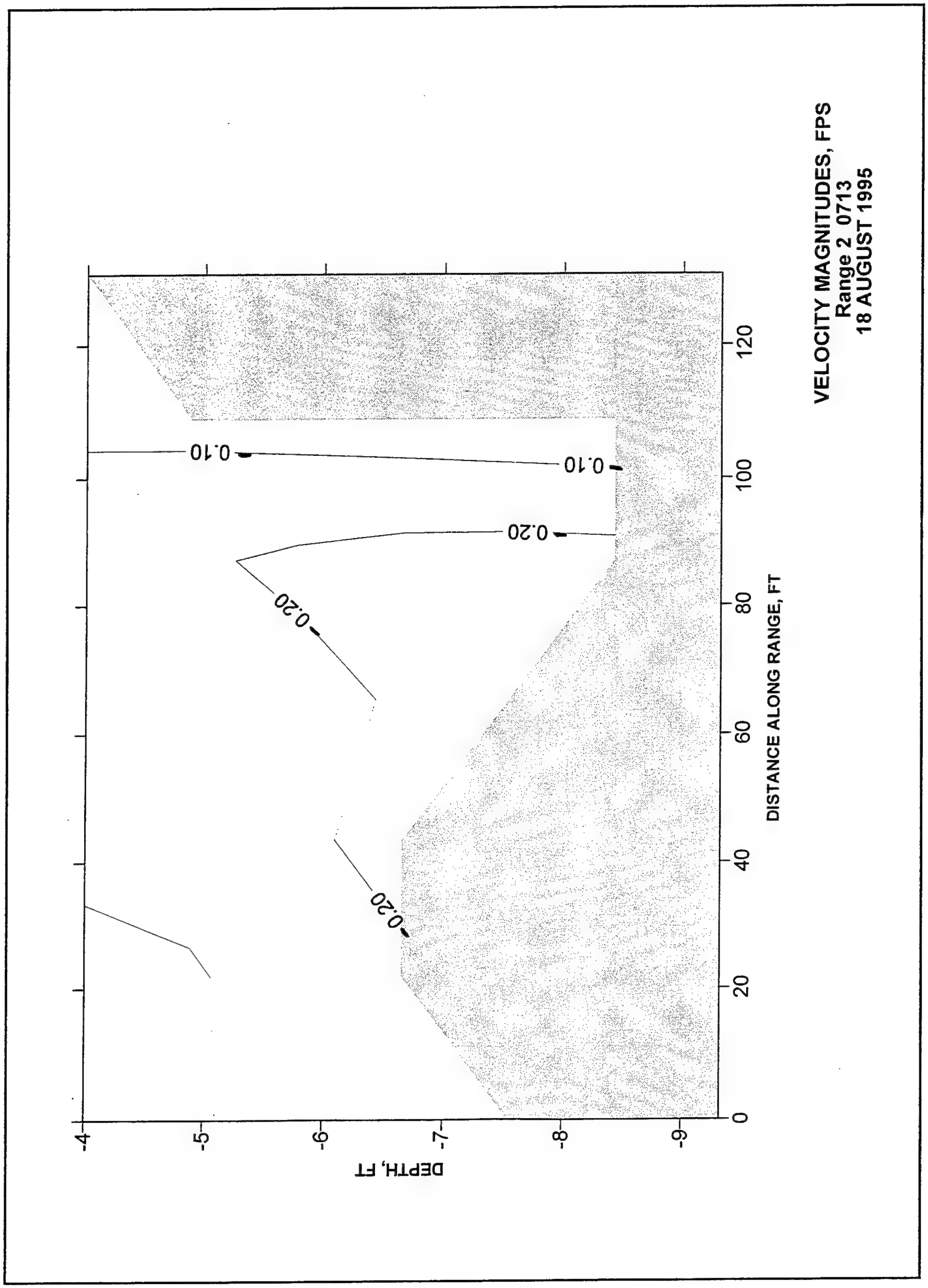
VELOCITY MAGNITUDES, FPS
Range 1 1037
18 AUGUST 1995

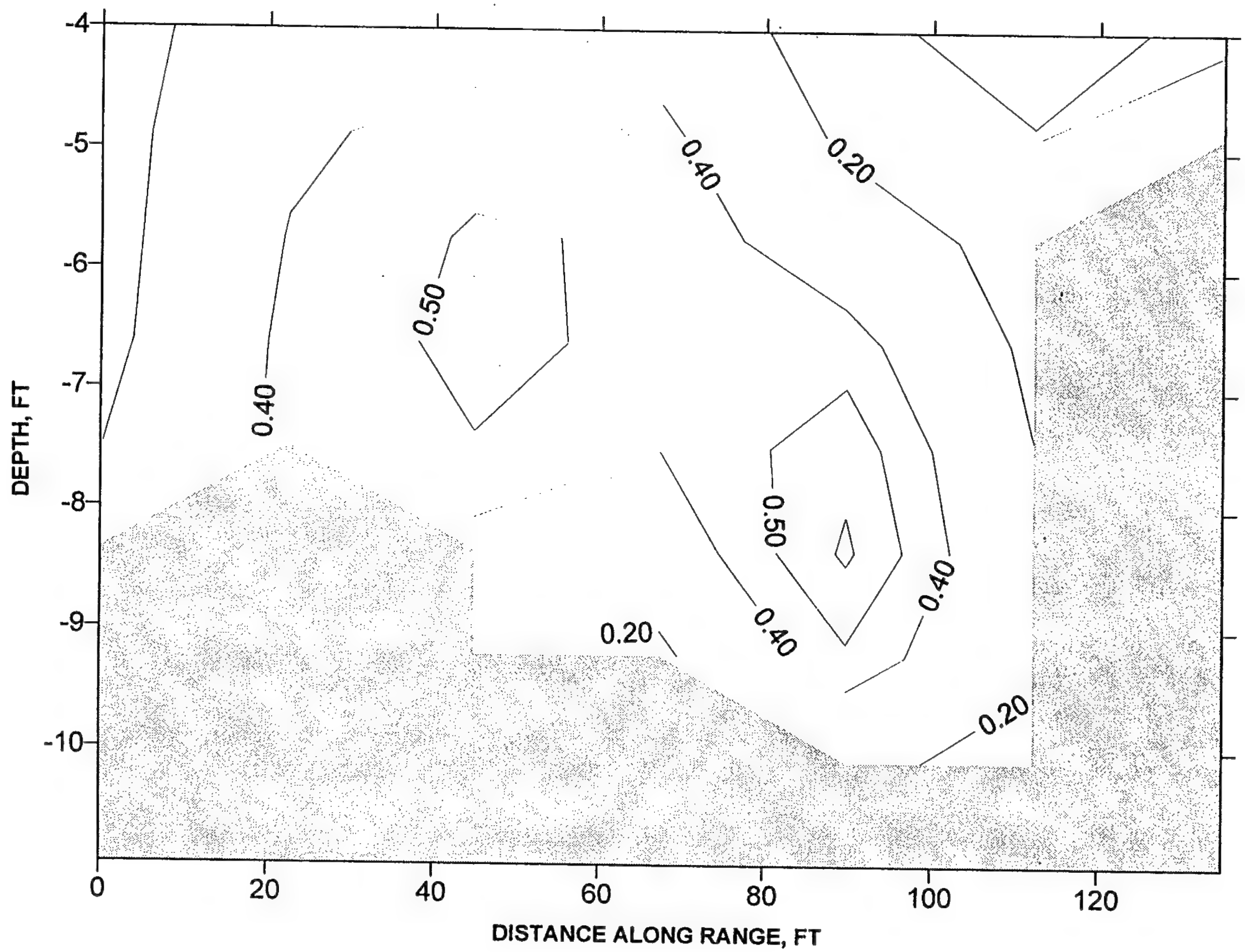


VELOCITY MAGNITUDES, FPS
Range 1 1251
18 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 1 1600
18 AUGUST 1995


VELOCITY MAGNITUDES, FPS
Range 2 0713
18 AUGUST 1995
DISTANCE ALONG RANGE, FT
0
20
40
60
80
100
120
DEPTH, FT
-4
-5
-6
-7
-8
-9
0.10
0.10
0.20
0.20
0.20



VELOCITY MAGNITUDES, FPS
Range 2 0914
18 AUGUST 1995

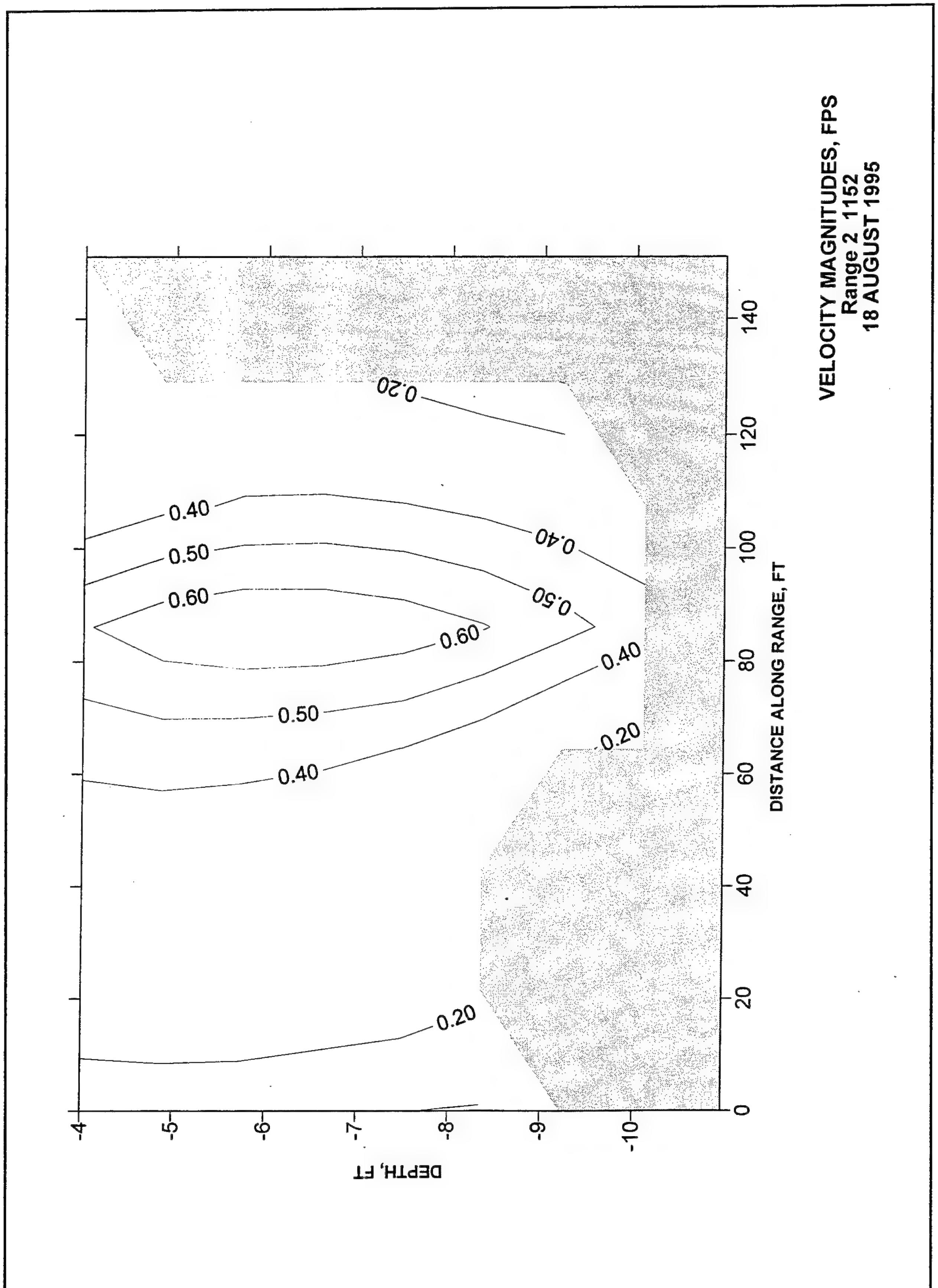
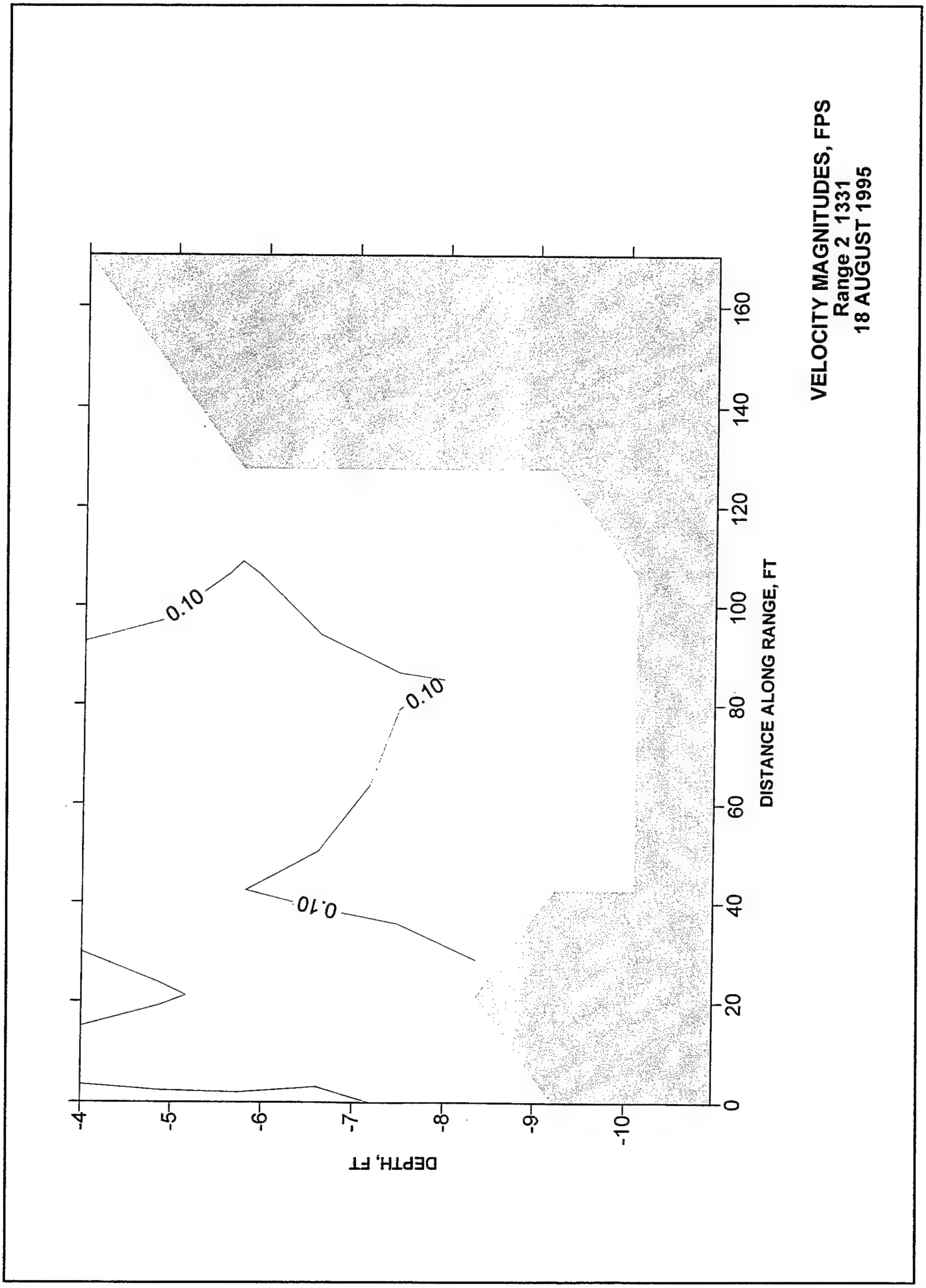
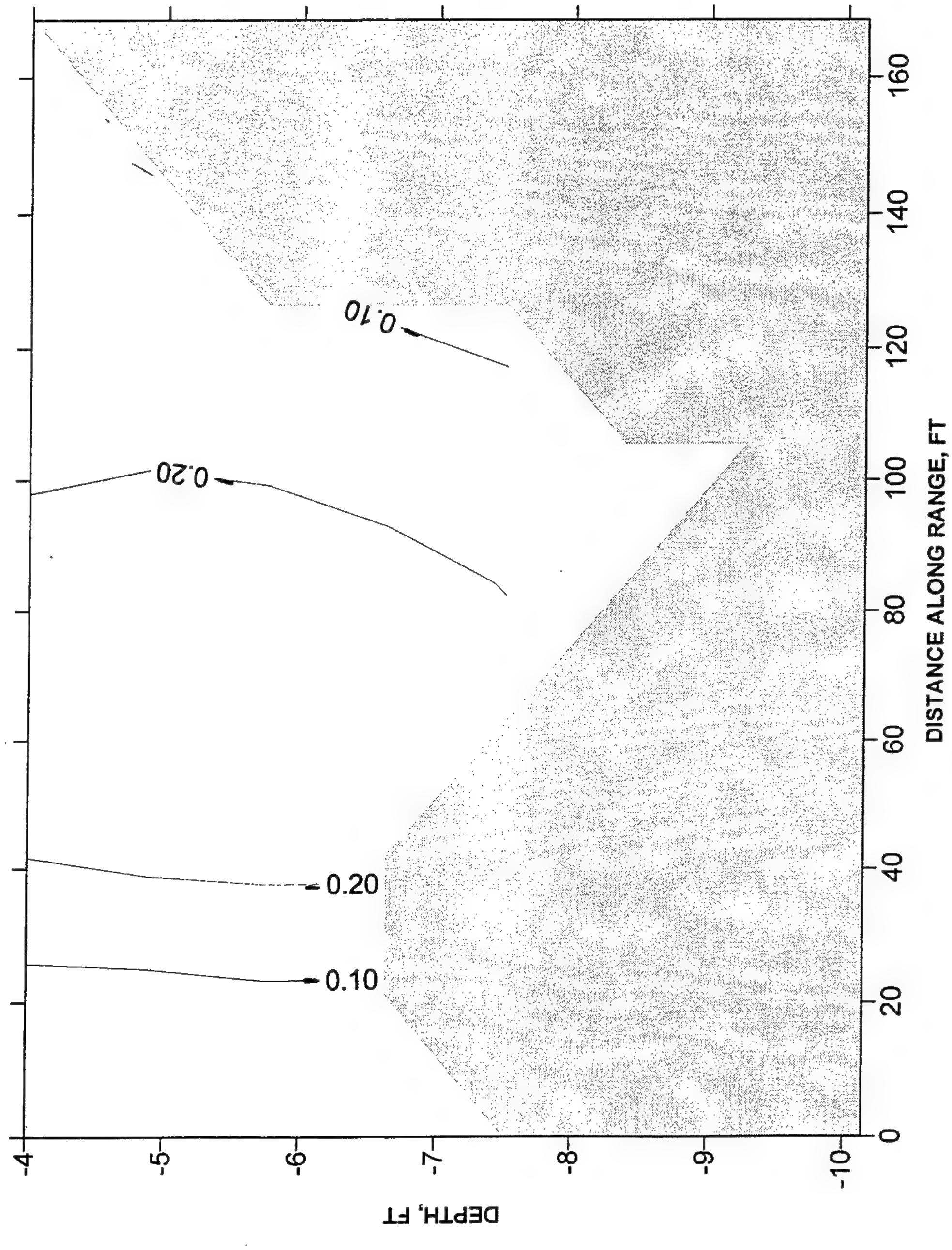

VELOCITY MAGNITUDES, FPS
Range 2 1152
18 AUGUST 1995
DEPTH, FT
DISTANCE ALONG RANGE, FT
-4
-5
-6
-7
-8
-9
-10
0
20
40
60
80
100
120
140
0.20
0.40
0.50
0.60
0.60
0.50
0.40
0.40
0.50
0.40
0.20
0.20

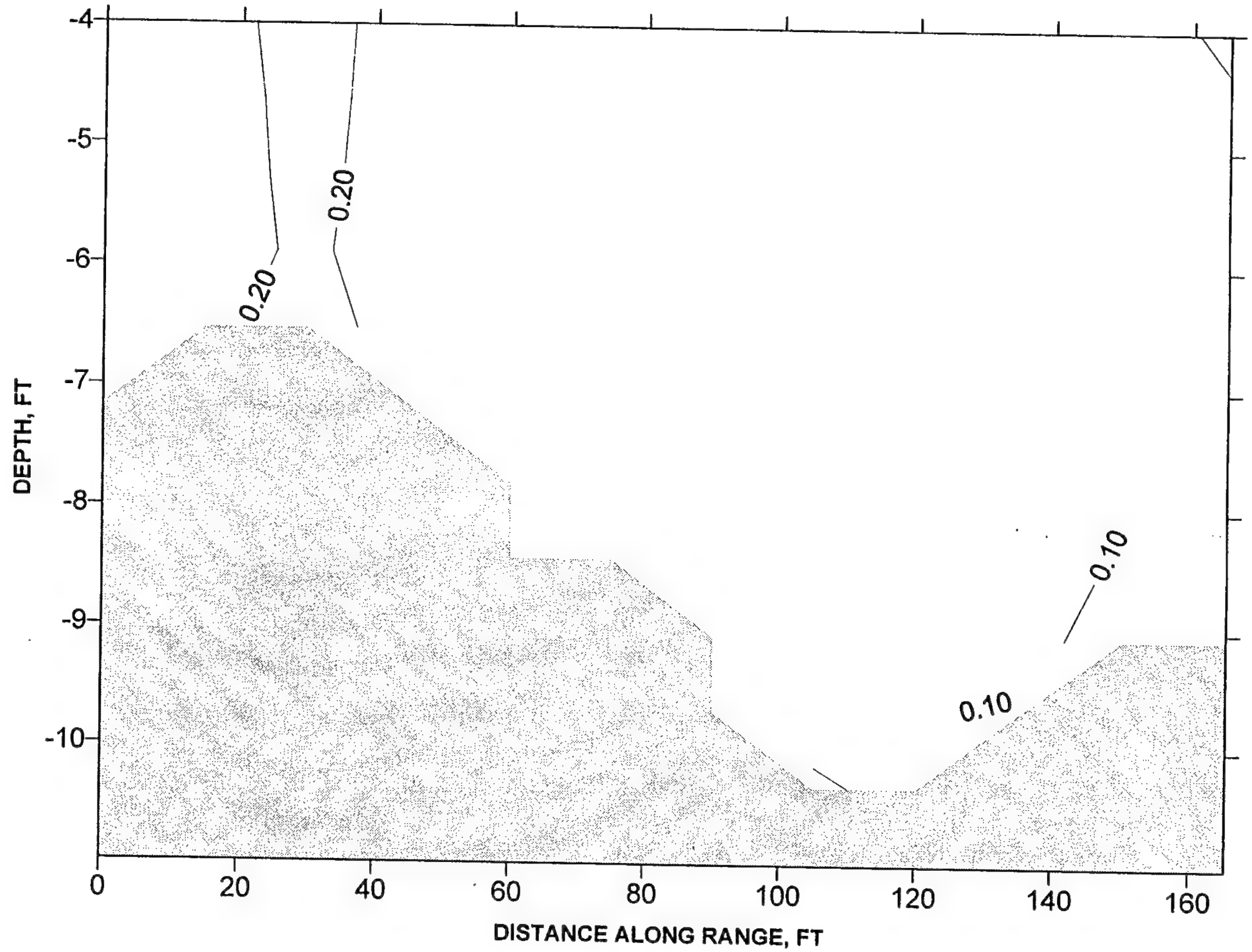
Plate 76



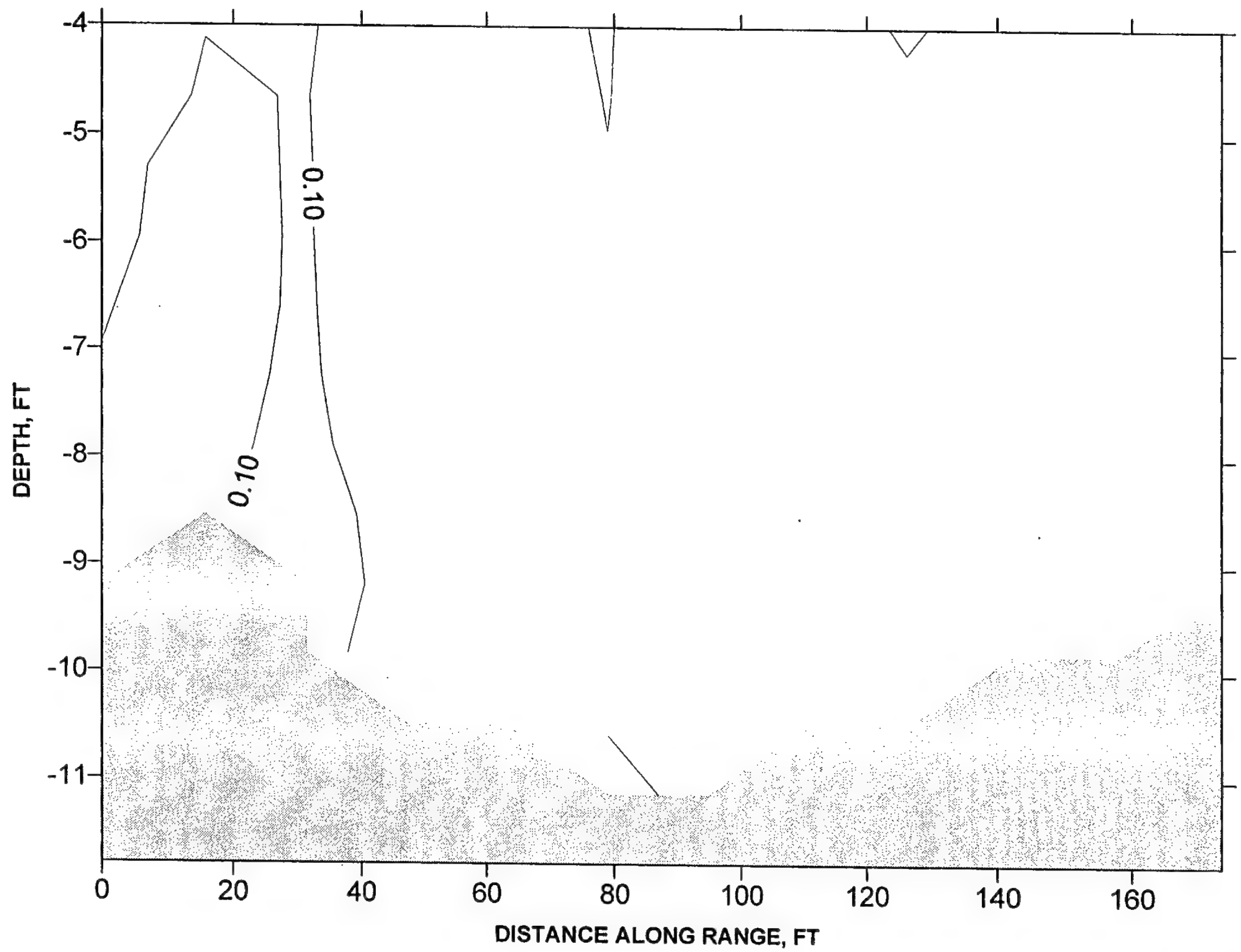
VELOCITY MAGNITUDES, FPS
Range 2 1331
18 AUGUST 1995
DEPTH, FT
DISTANCE ALONG RANGE, FT
0.10
0.10
0.10
-4
-5
-6
-7
-8
-9
-10
0
20
40
60
80
100
120
140
160



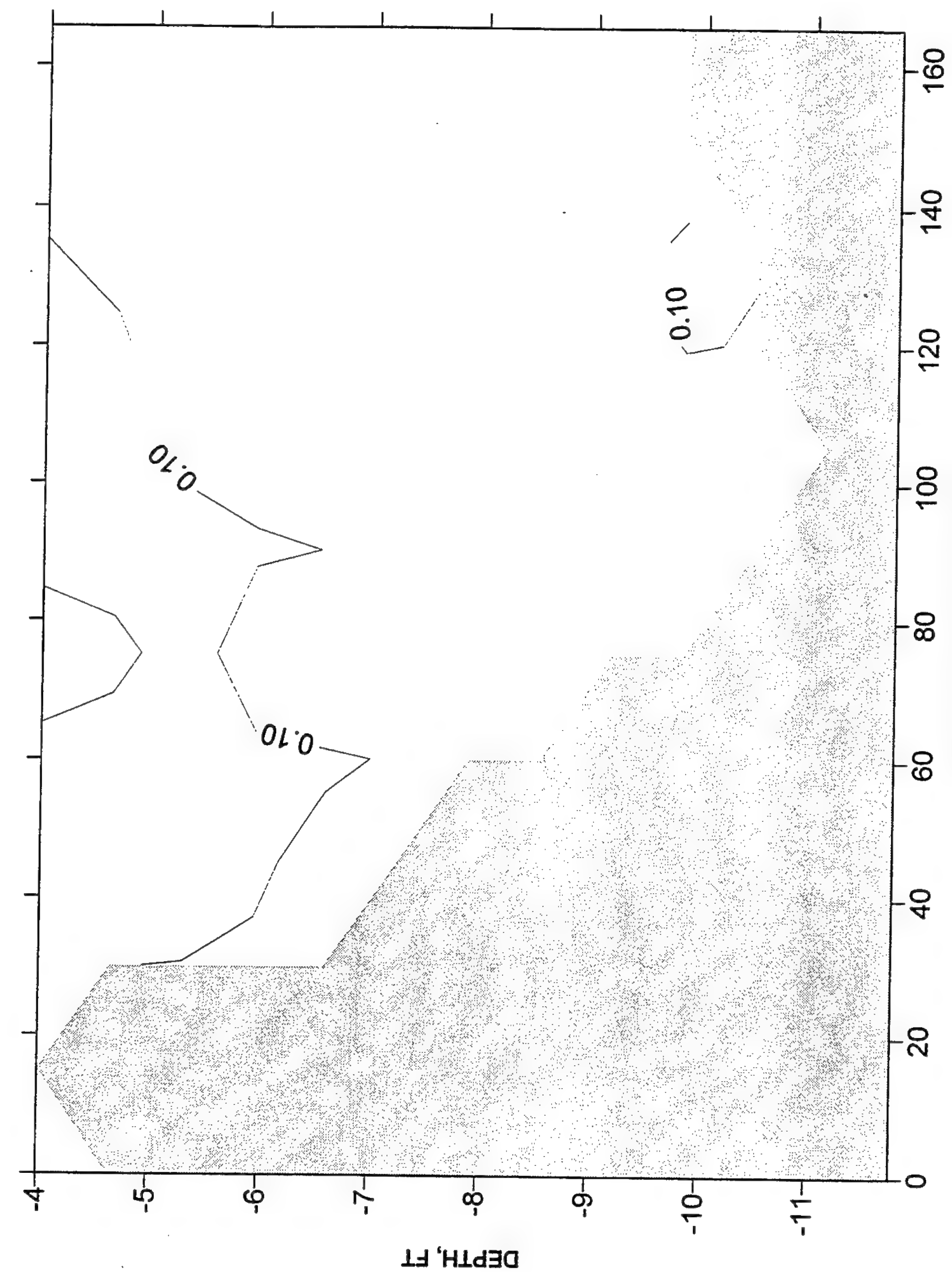
VELOCITY MAGNITUDES, FPS
Range 2 1614
18 AUGUST 1995



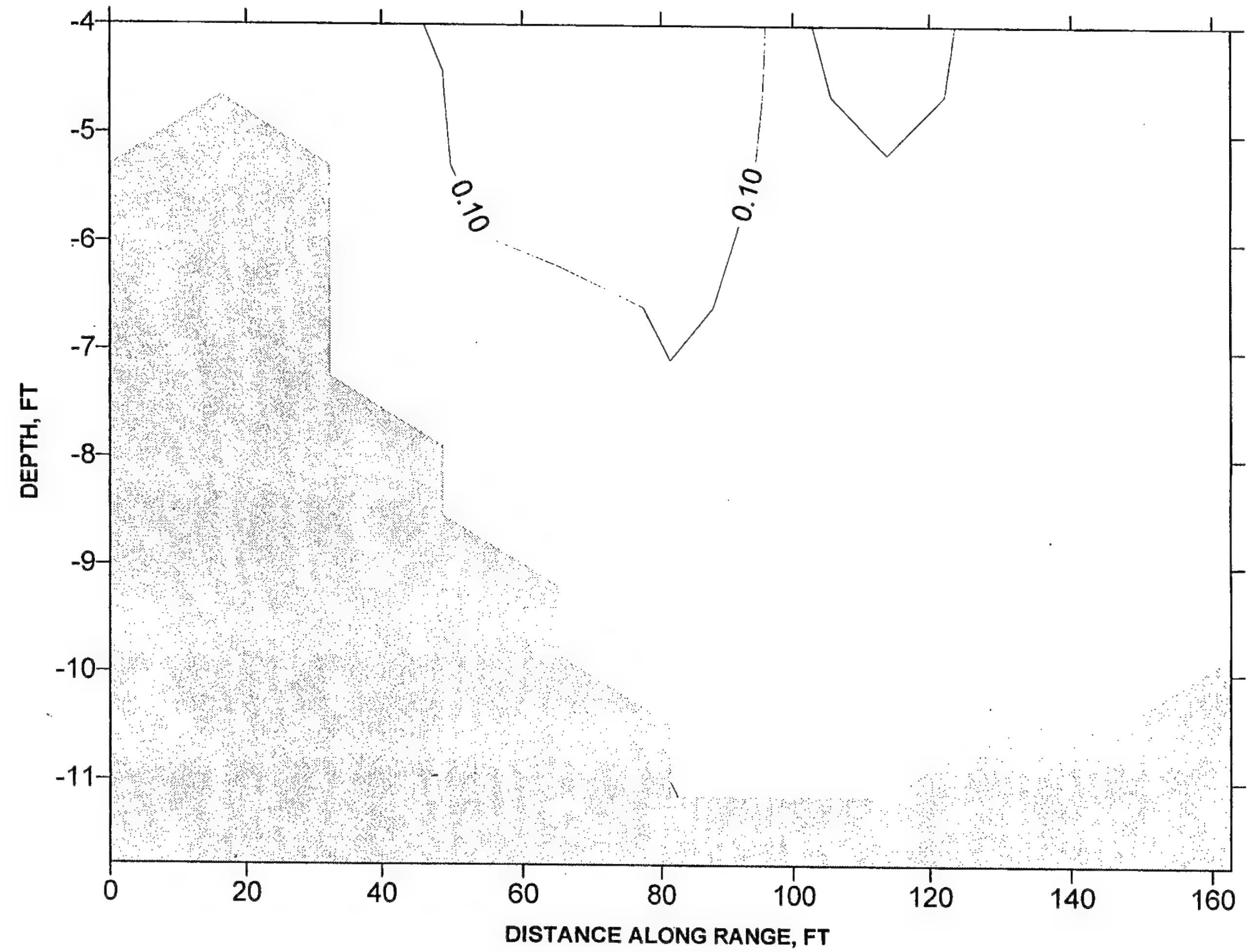
VELOCITY MAGNITUDES, FPS
Range 3 0823
18 AUGUST 1995



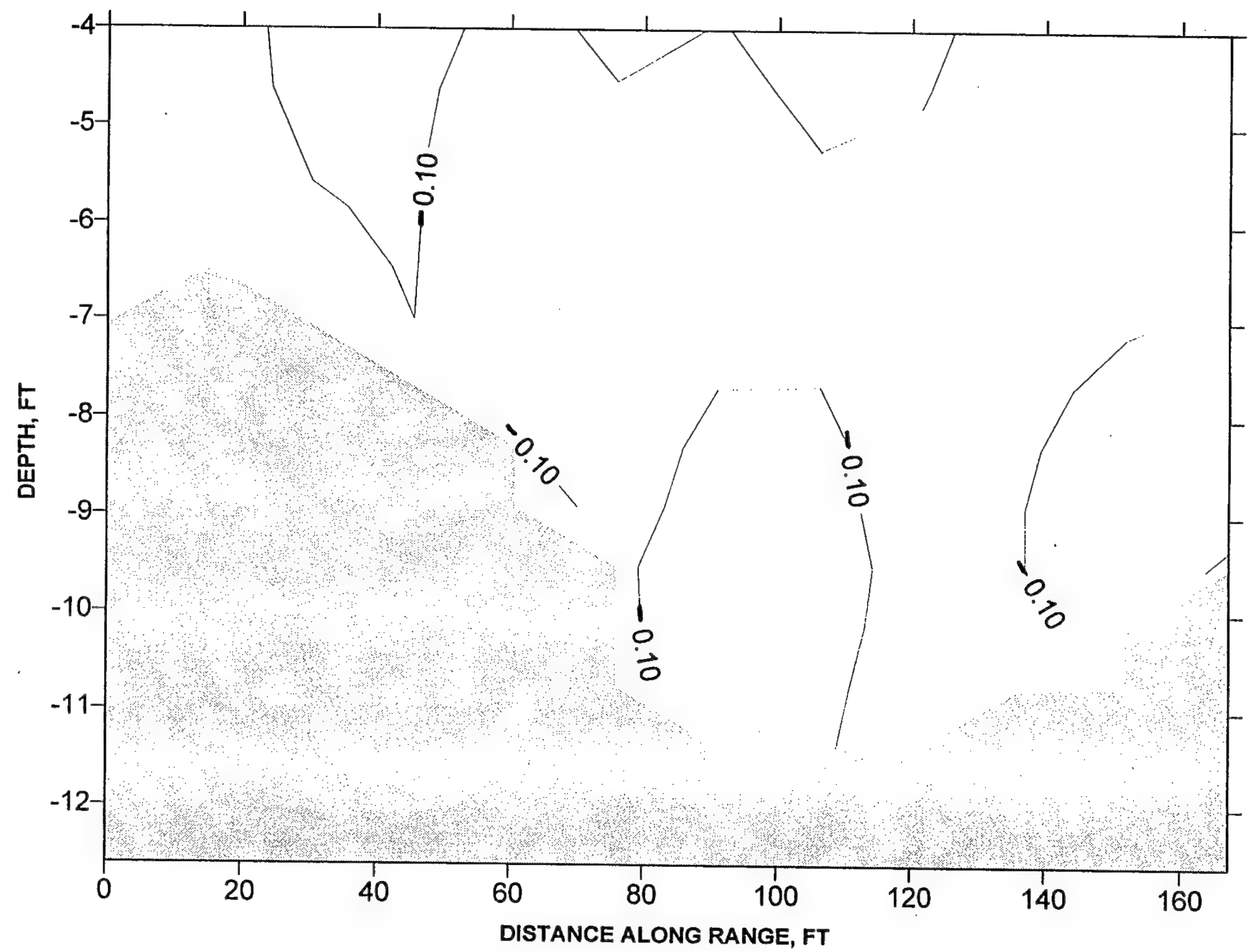
VELOCITY MAGNITUDES, FPS
Range 3 1001
18 AUGUST 1995



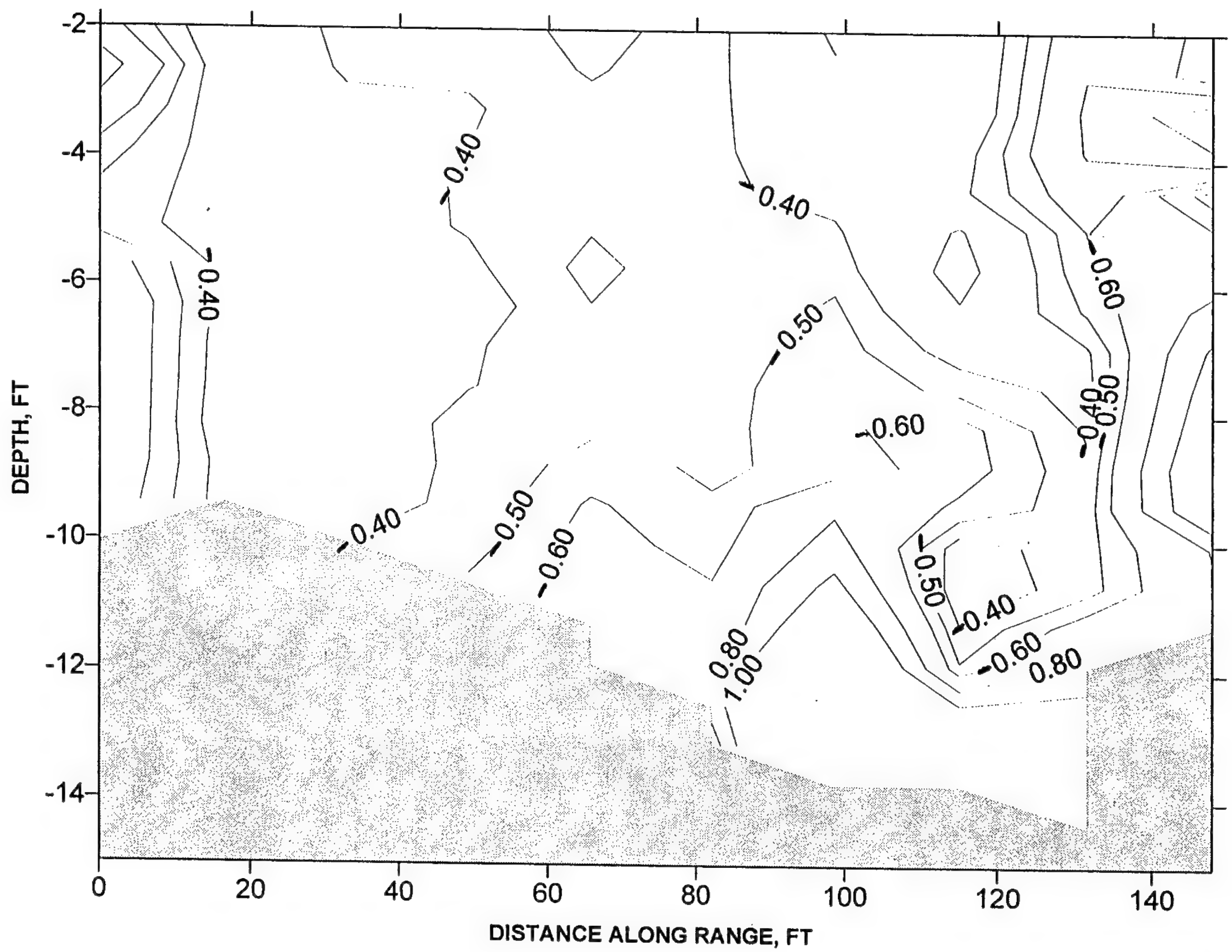
VELOCITY MAGNITUDES, FPS
Range 3 1213
18 AUGUST 1995



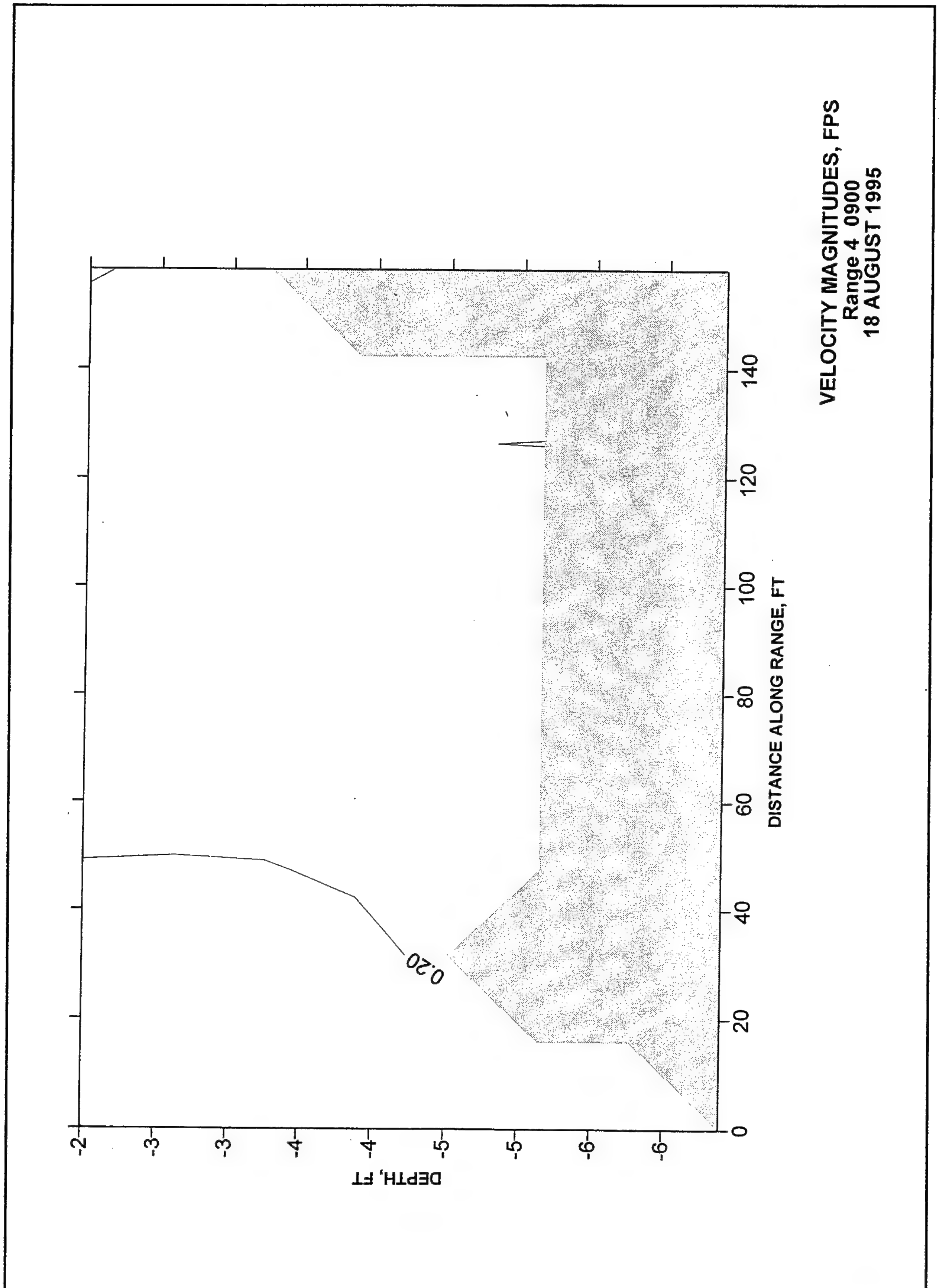
VELOCITY MAGNITUDES, FPS
Range 3 1450
18 AUGUST 1995

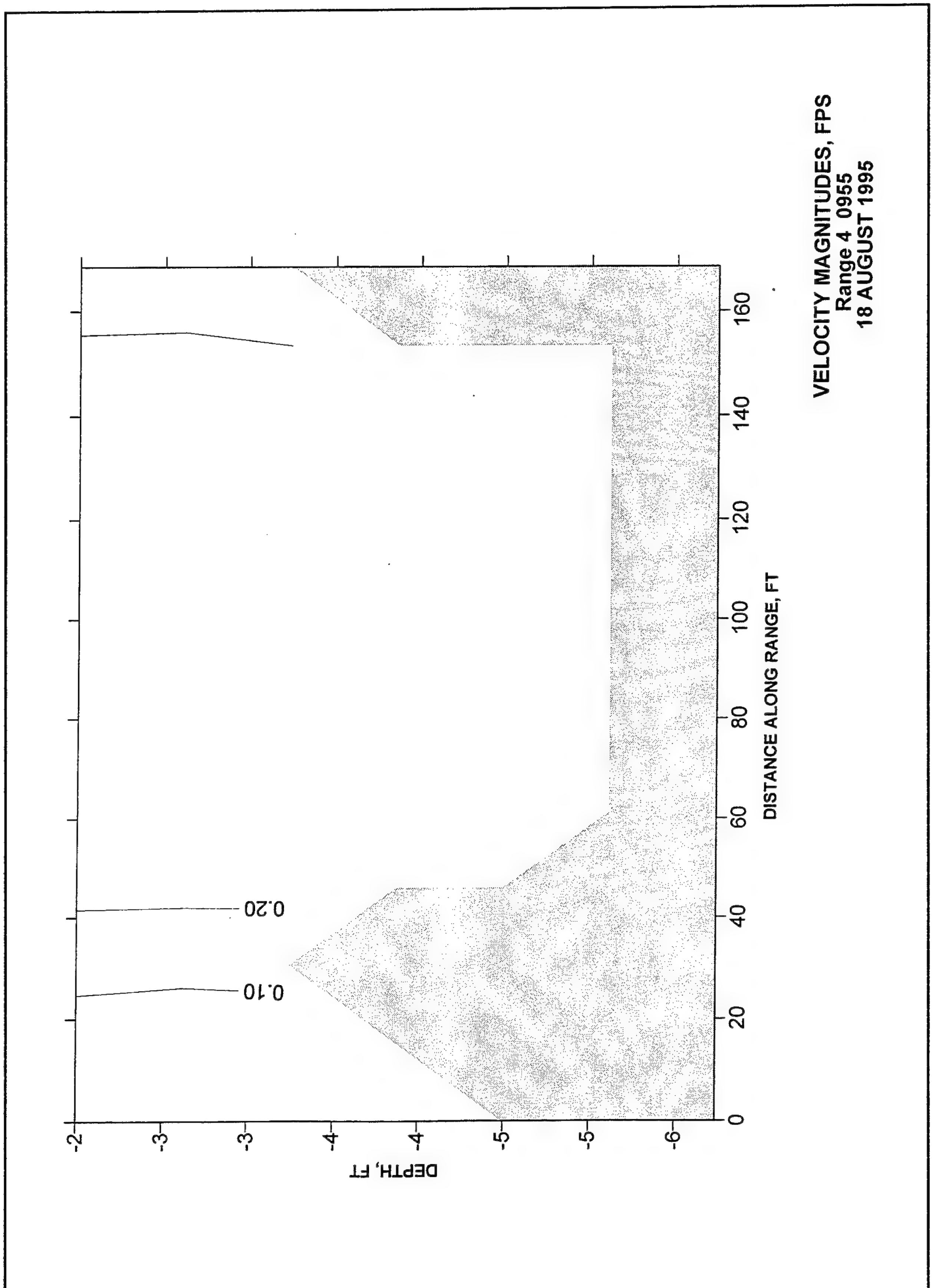


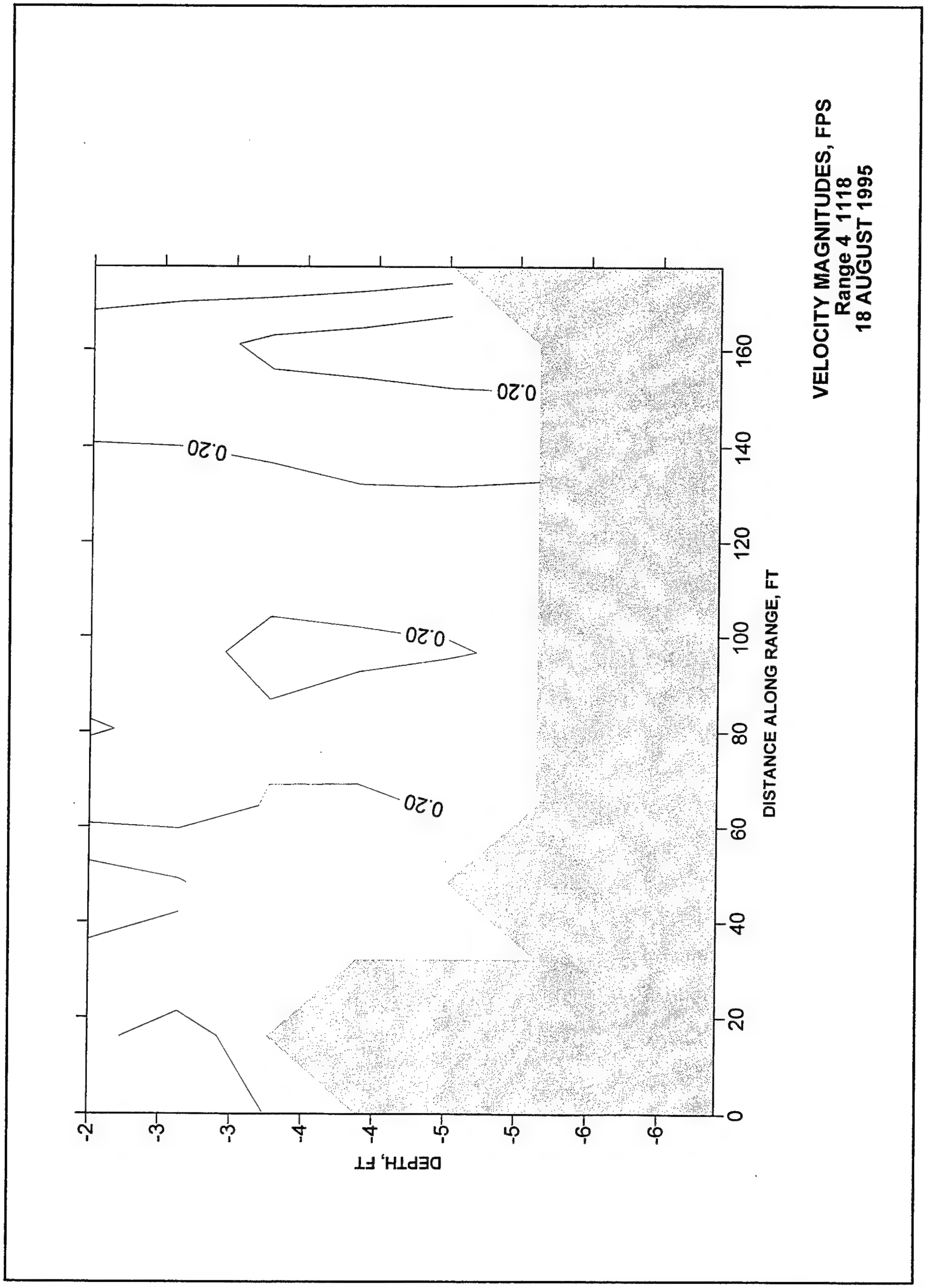
VELOCITY MAGNITUDES, FPS
Range 3 1647
18 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 4 0800
18 AUGUST 1995


VELOCITY MAGNITUDES, FPS
Range 4 0900
18 AUGUST 1995
DEPTH, FT
DISTANCE ALONG RANGE, FT
0.20
-2
-3
-3
-4
-4
-5
-5
-6
-6
0
20
40
60
80
100
120
140


VELOCITY MAGNITUDES, FPS
Range 4 0955
18 AUGUST 1995
DEPTH, FT
DISTANCE ALONG RANGE, FT
0.10
0.20
-2
-3
-3
-4
-4
-5
-5
-6
0
20
40
60
80
100
120
140
160


VELOCITY MAGNITUDES, FPS
Range 4 1118
18 AUGUST 1995
DEPTH, FT
DISTANCE ALONG RANGE, FT
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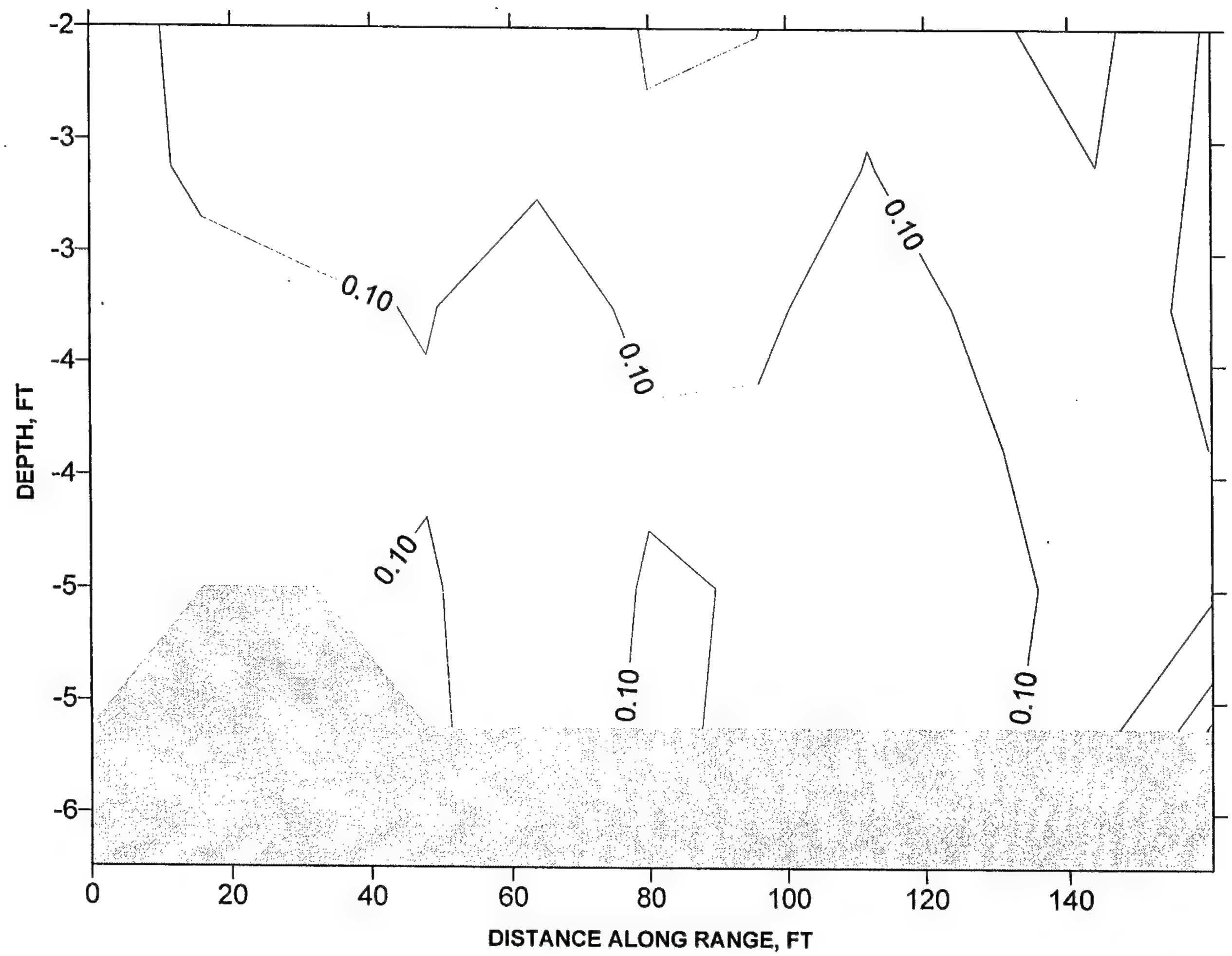
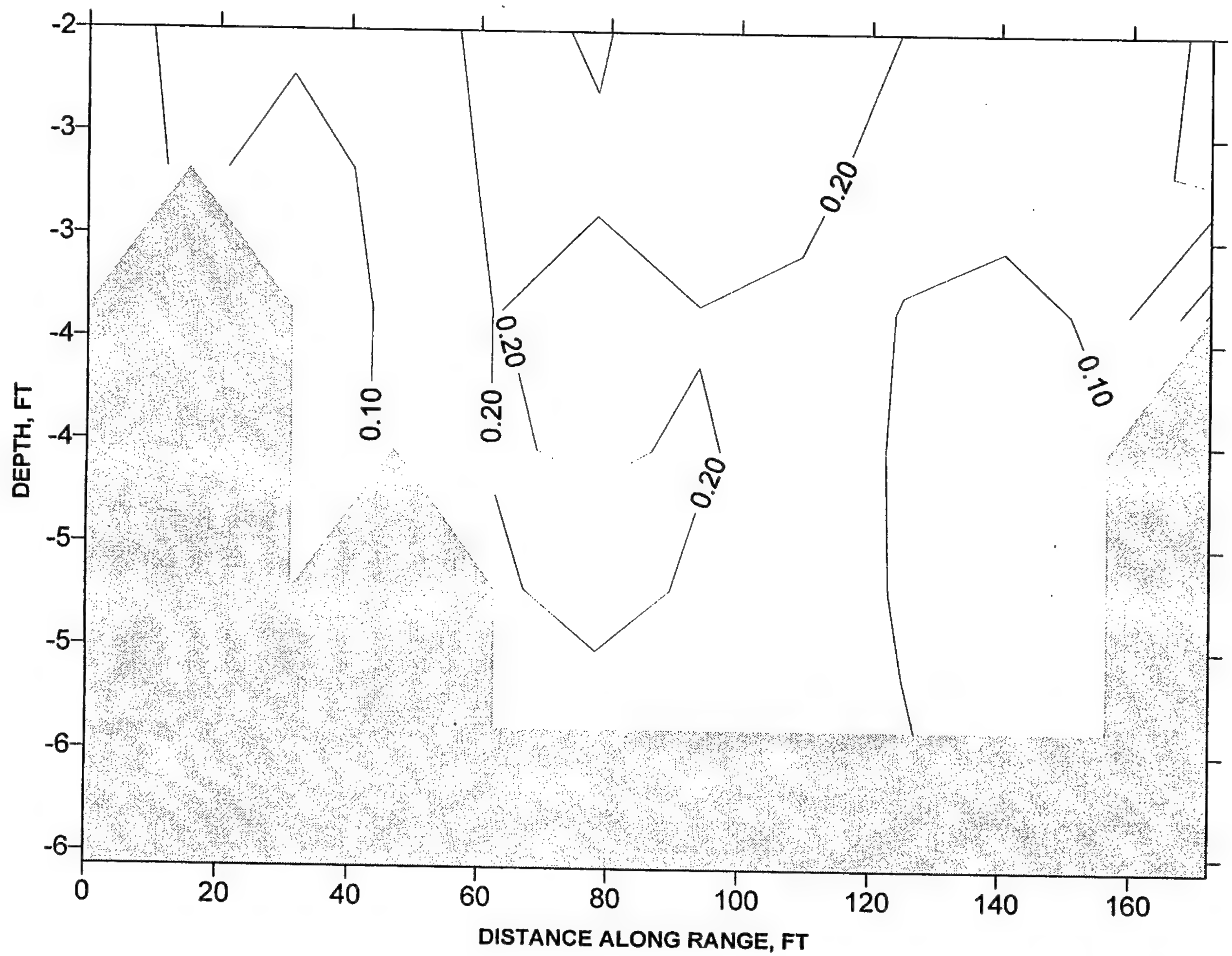
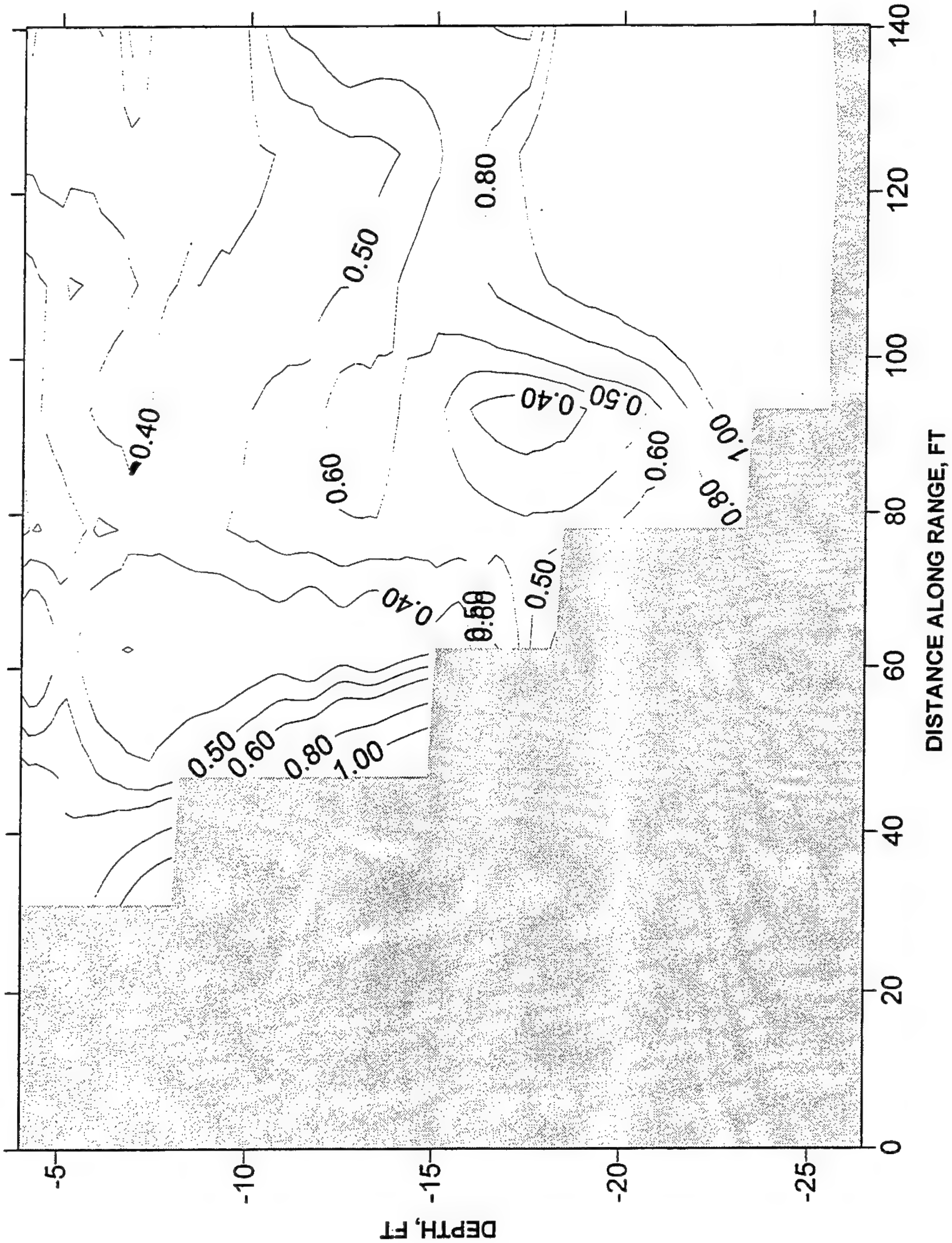
0.20
0.20
0.20
0 20 40 60 80 100 120 140 160
-2 -3 -3 -4 -4 -5 -5 -6 -6



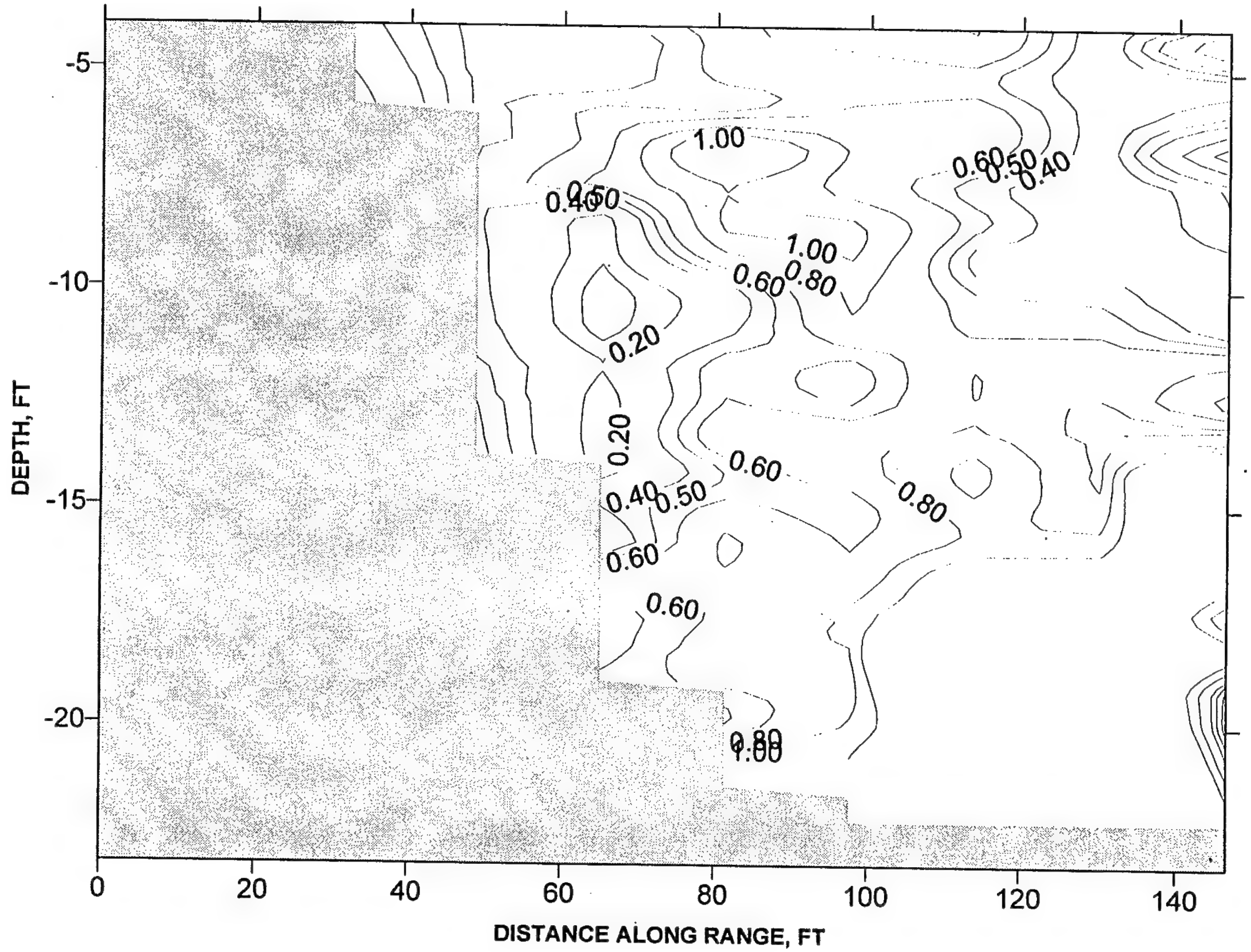
VELOCITY MAGNITUDES, FPS
Range 4 1230
18 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 4 1407
18 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 5 0820
18 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 5 0917
18 AUGUST 1995

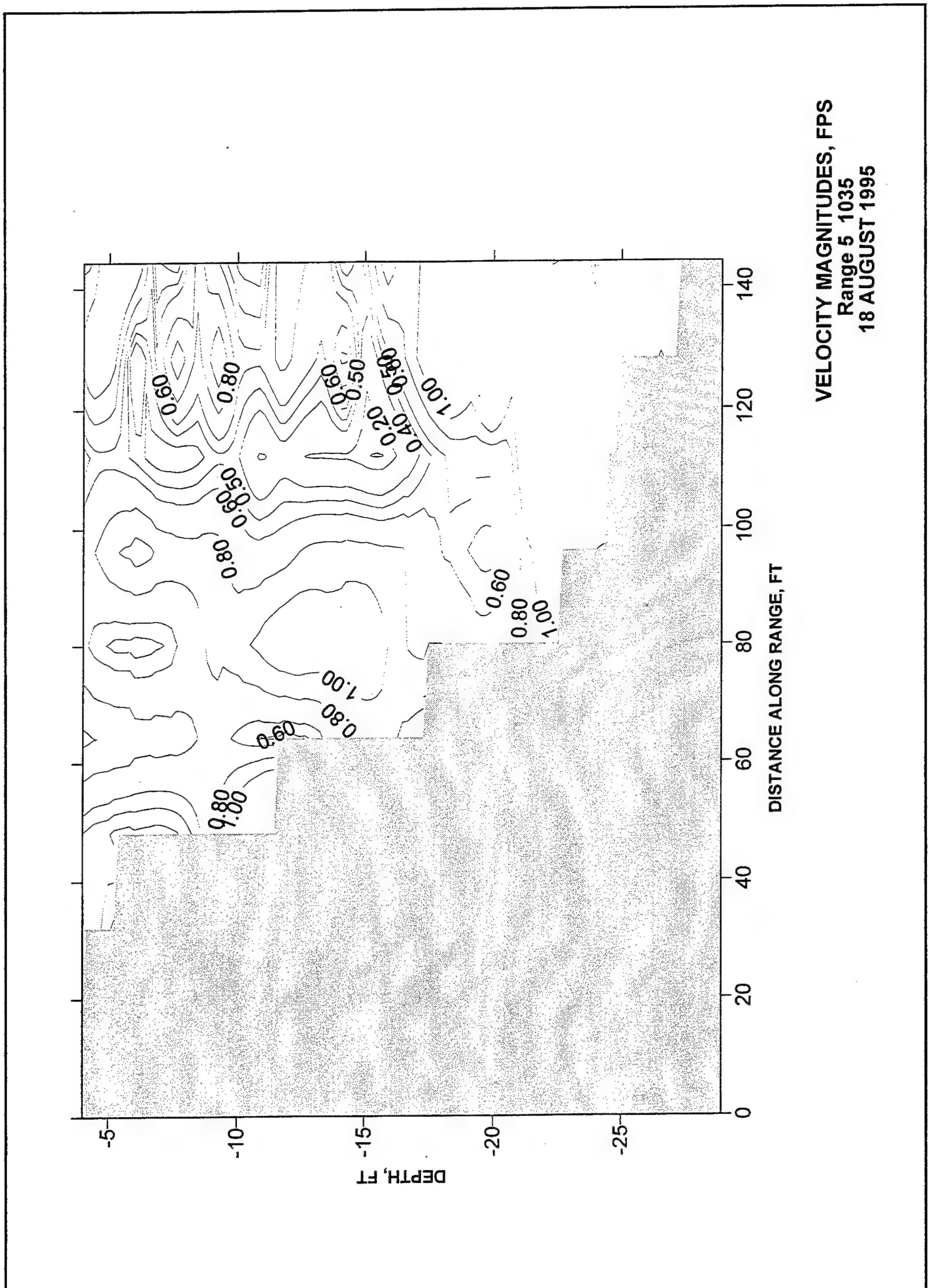
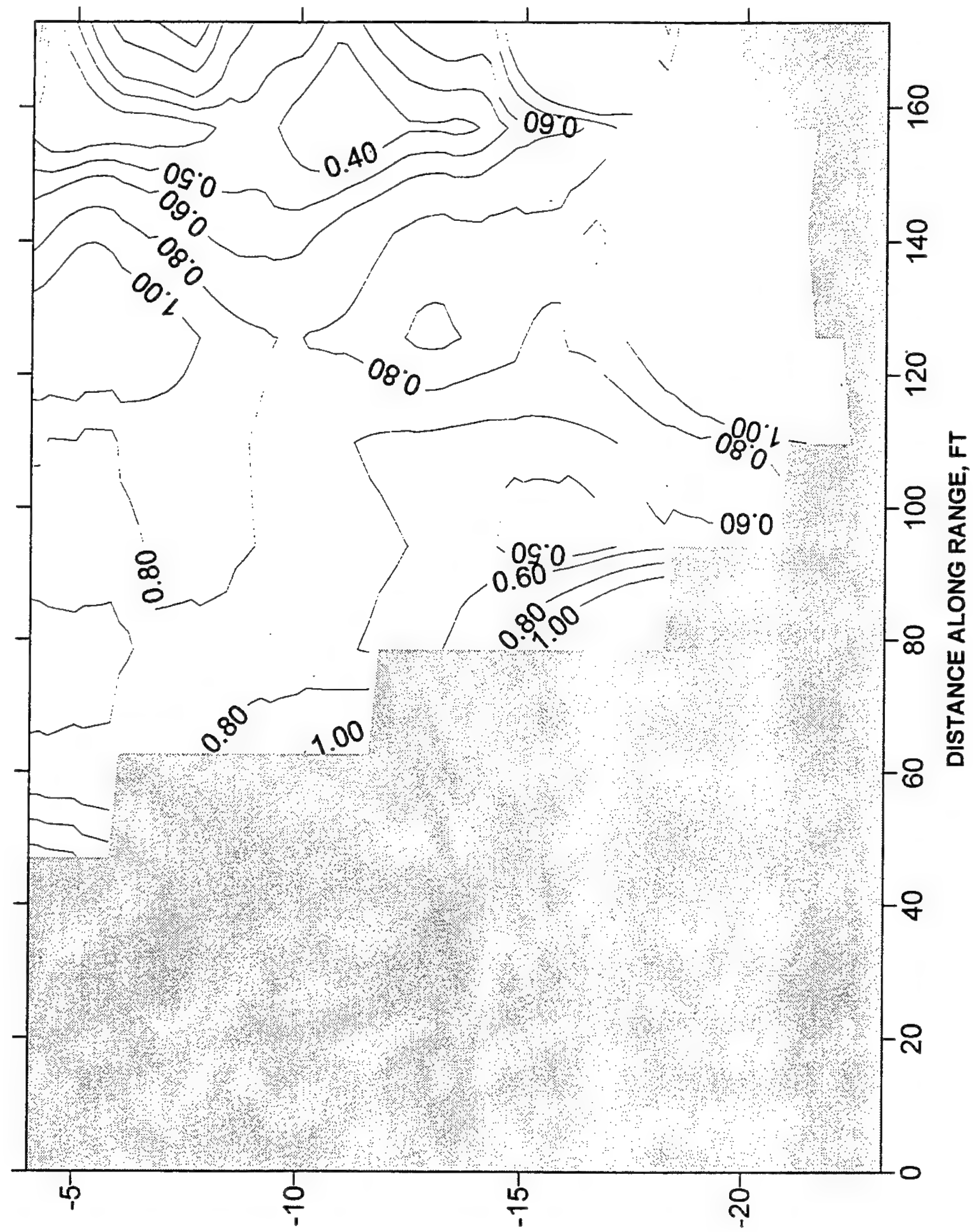
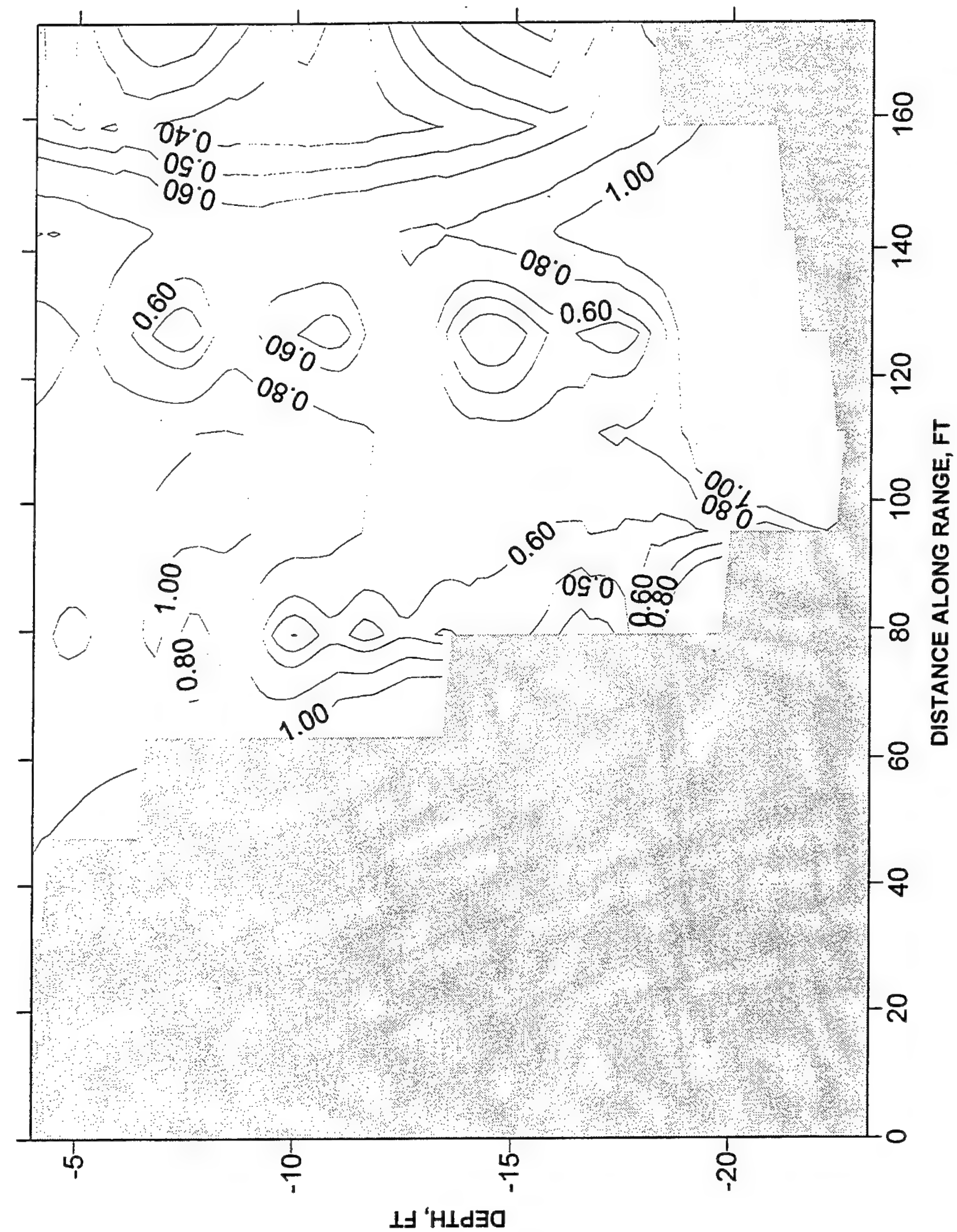

VELOCITY MAGNITUDES, FPS
Range 5 1035
18 AUGUST 1995
DISTANCE ALONG RANGE, FT
DEPTH, FT
0
20
40
60
80
100
120
140
-5
-10
-15
-20
-25
0.60
0.80
1.00
0.50
0.20
0.40

Plate 92

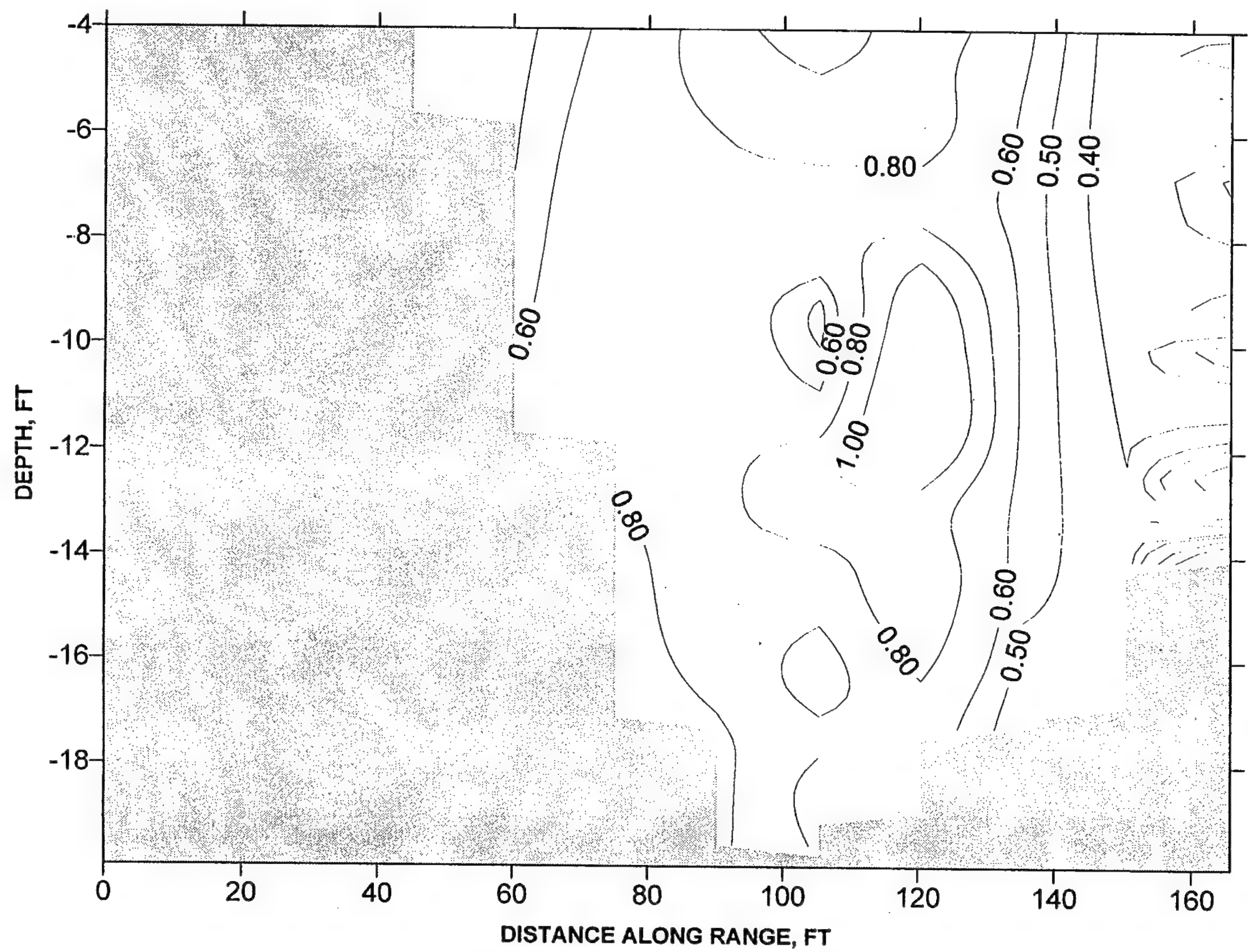


VELOCITY MAGNITUDES, FPS
Range 5 1145
18 AUGUST 1995

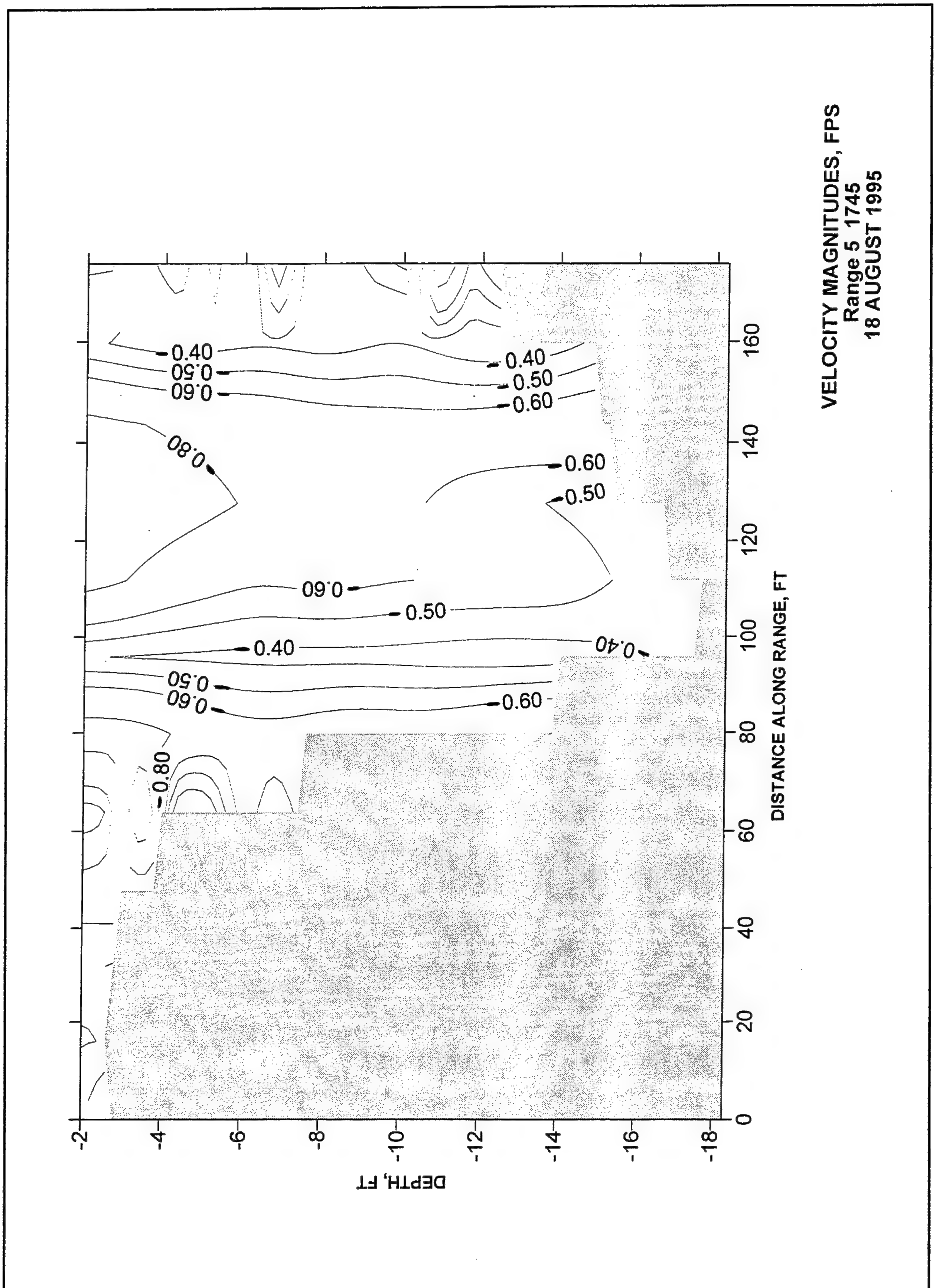


VELOCITY MAGNITUDES, FPS
Range 5 1255
18 AUGUST 1995

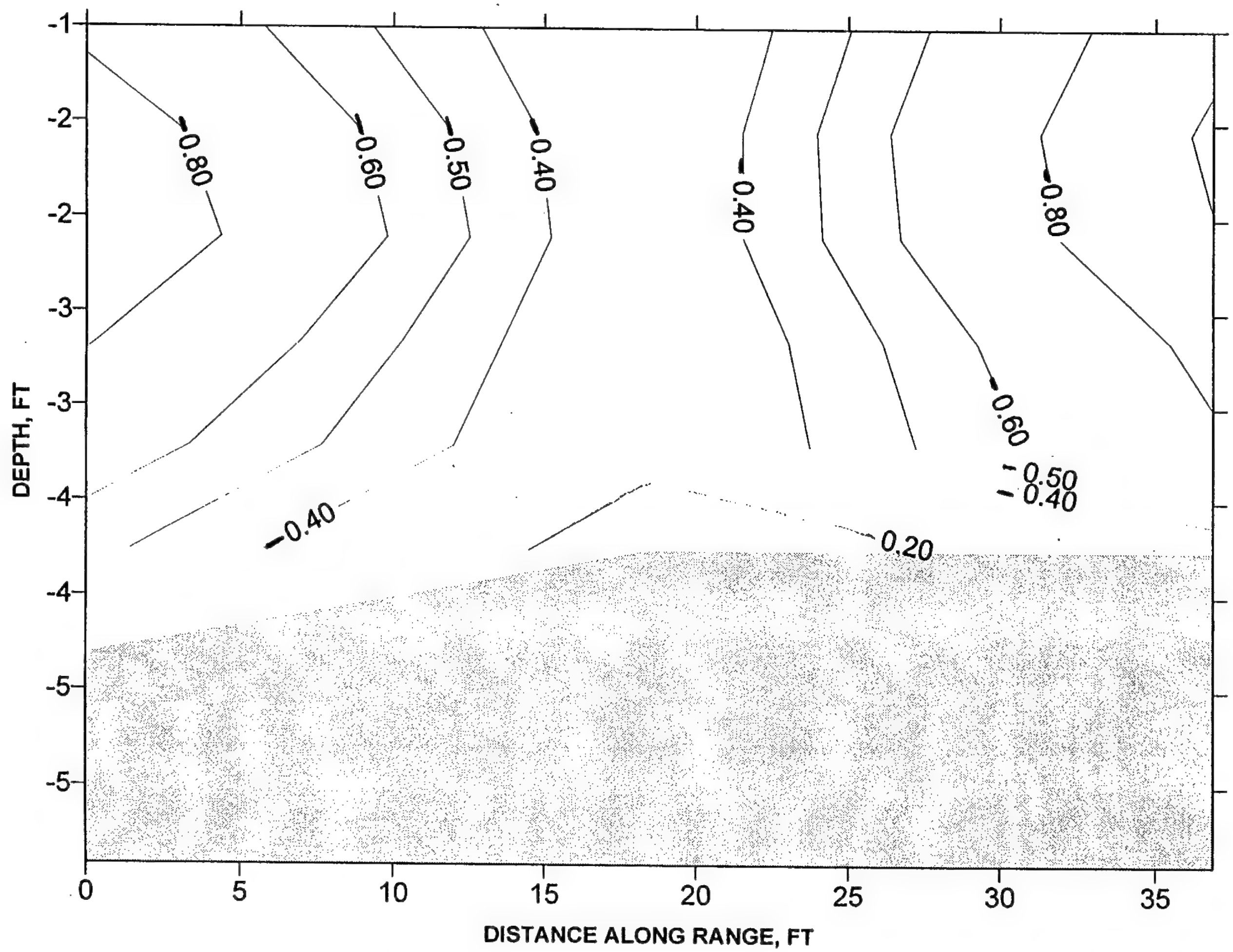
Plate 94



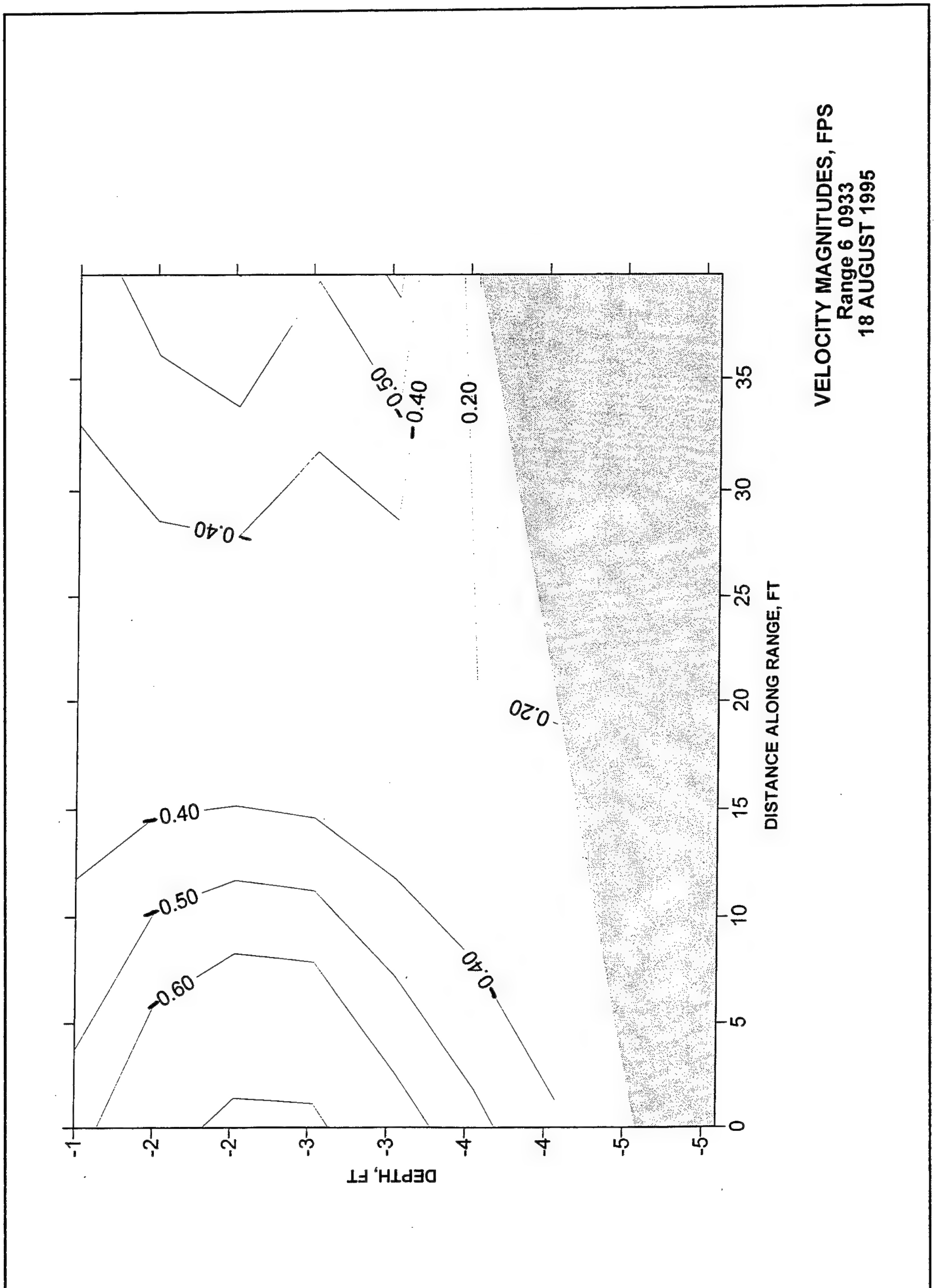
VELOCITY MAGNITUDES, FPS
Range 5 1428
18 AUGUST 1995



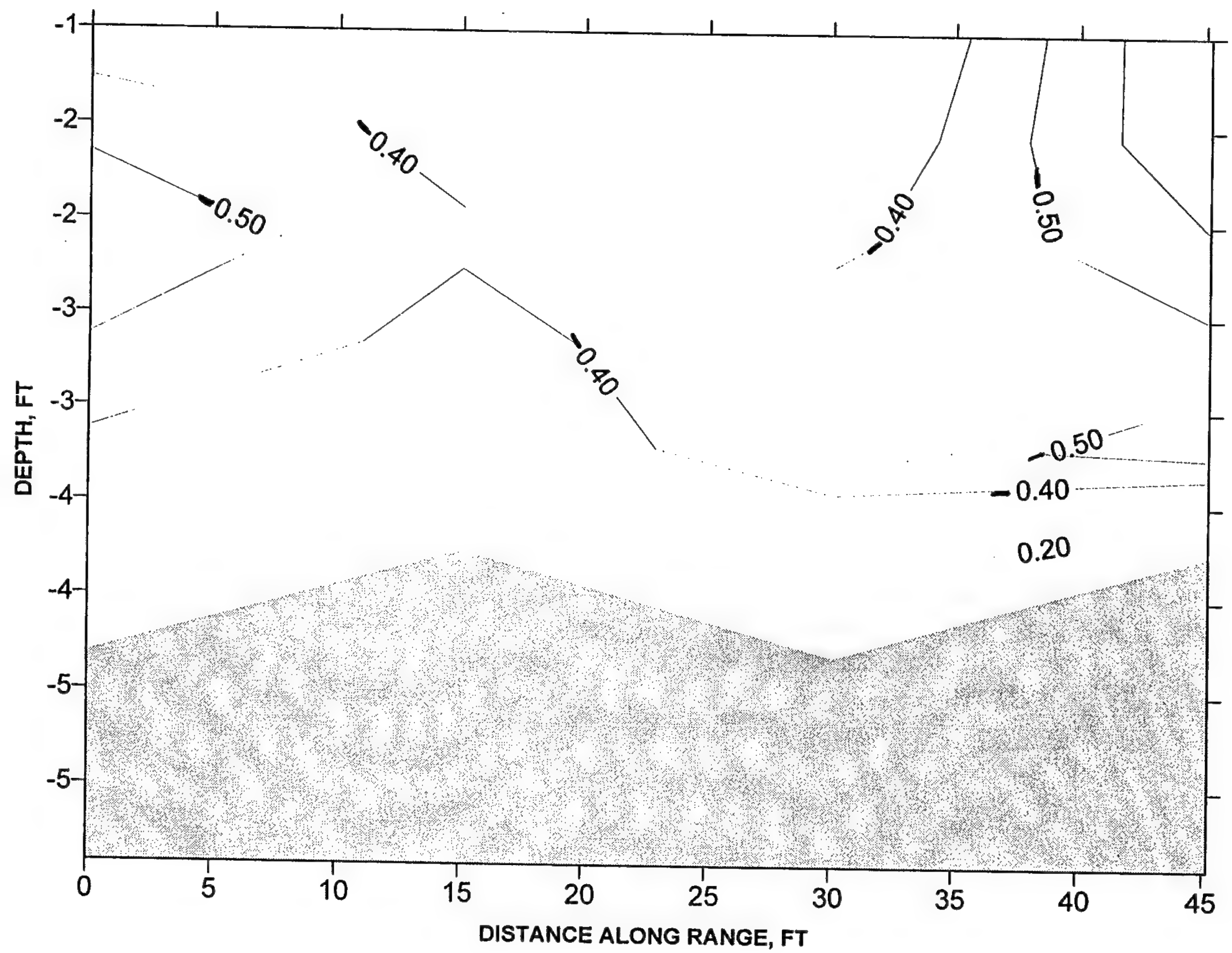
VELOCITY MAGNITUDES, FPS
Range 5 1745
18 AUGUST 1995
DEPTH, FT
DISTANCE ALONG RANGE, FT
0.40
0.50
0.60
0.80



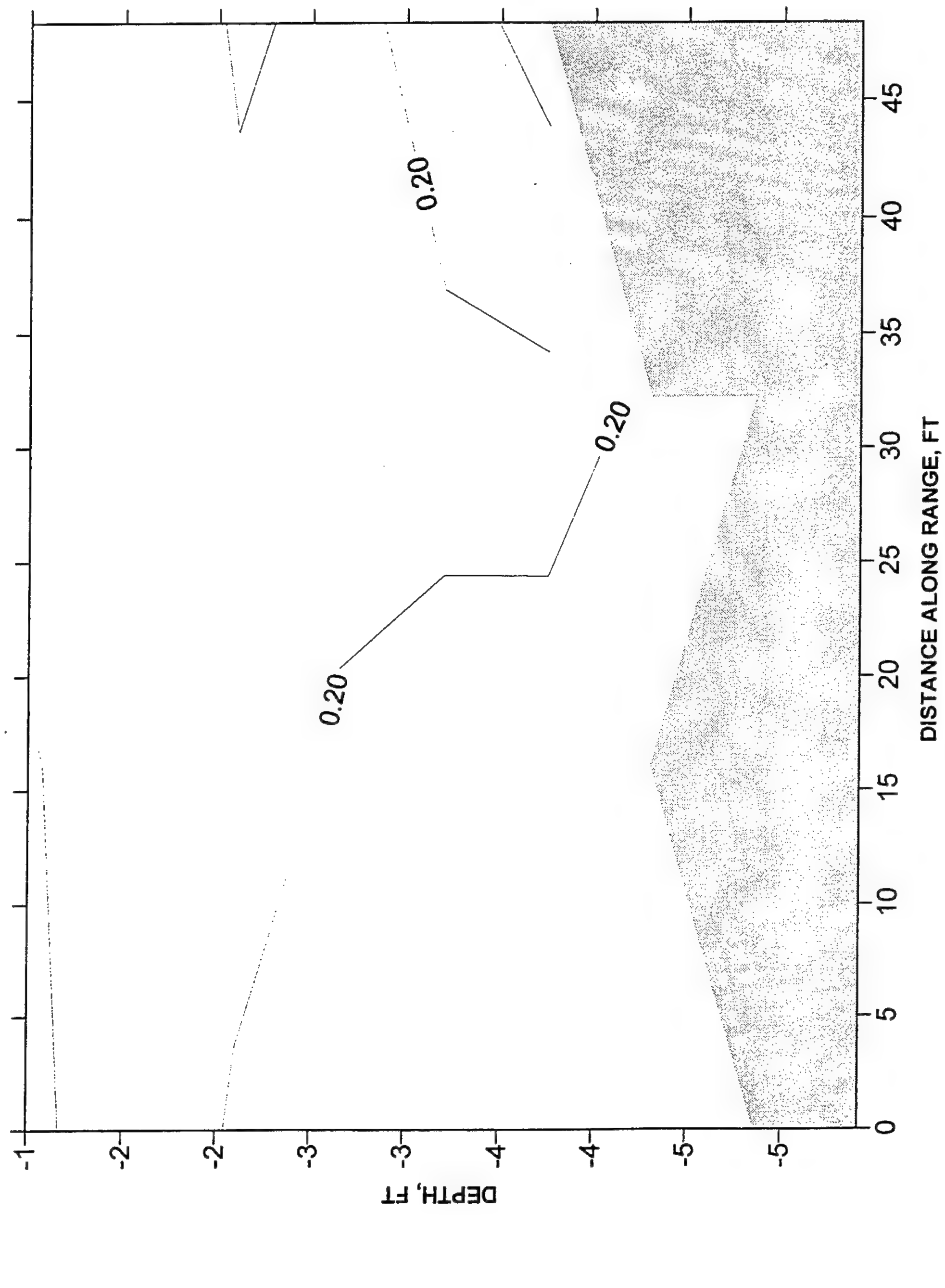
VELOCITY MAGNITUDES, FPS
Range 6 0835
18 AUGUST 1995



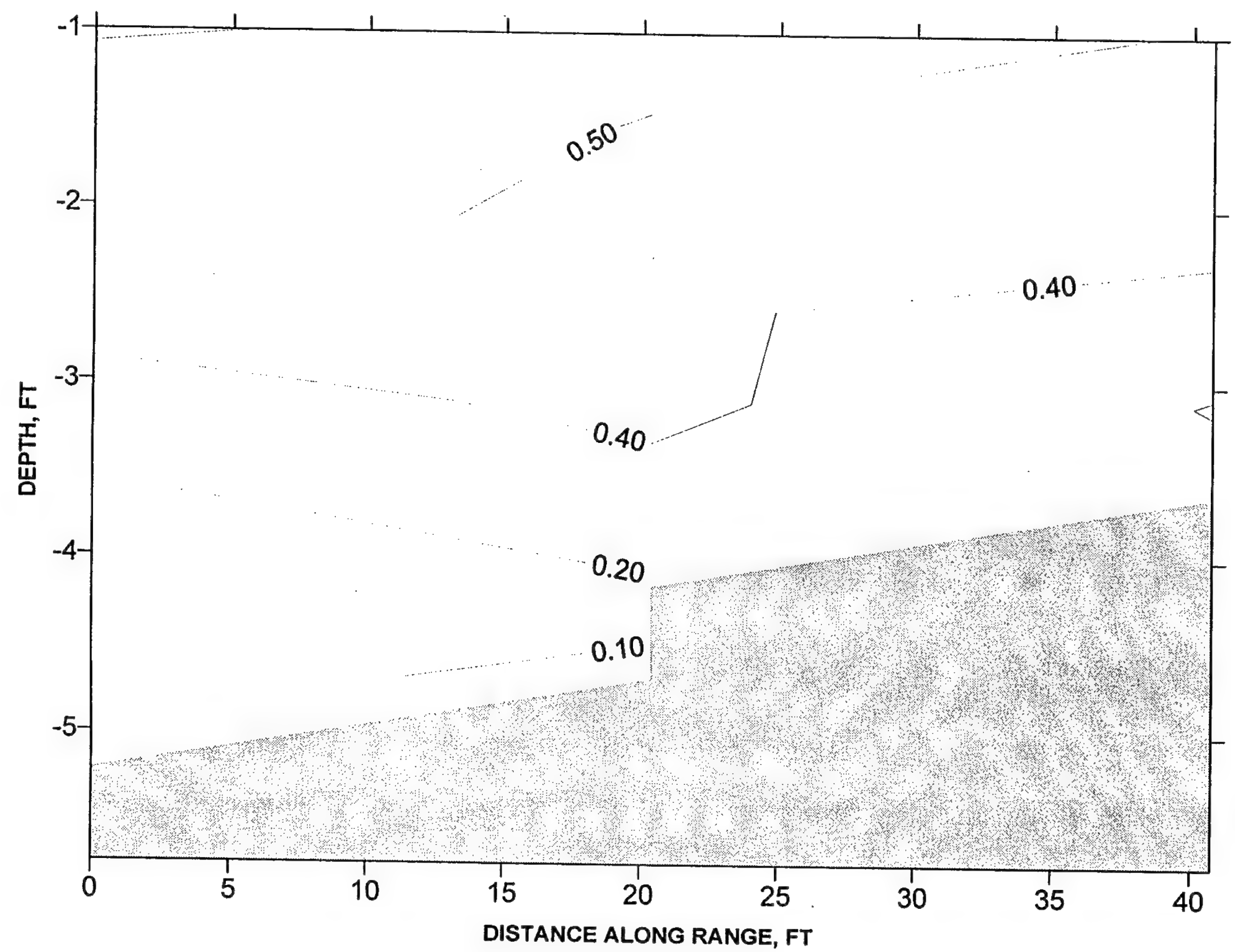
VELOCITY MAGNITUDES, FPS
Range 6 0933
18 AUGUST 1995



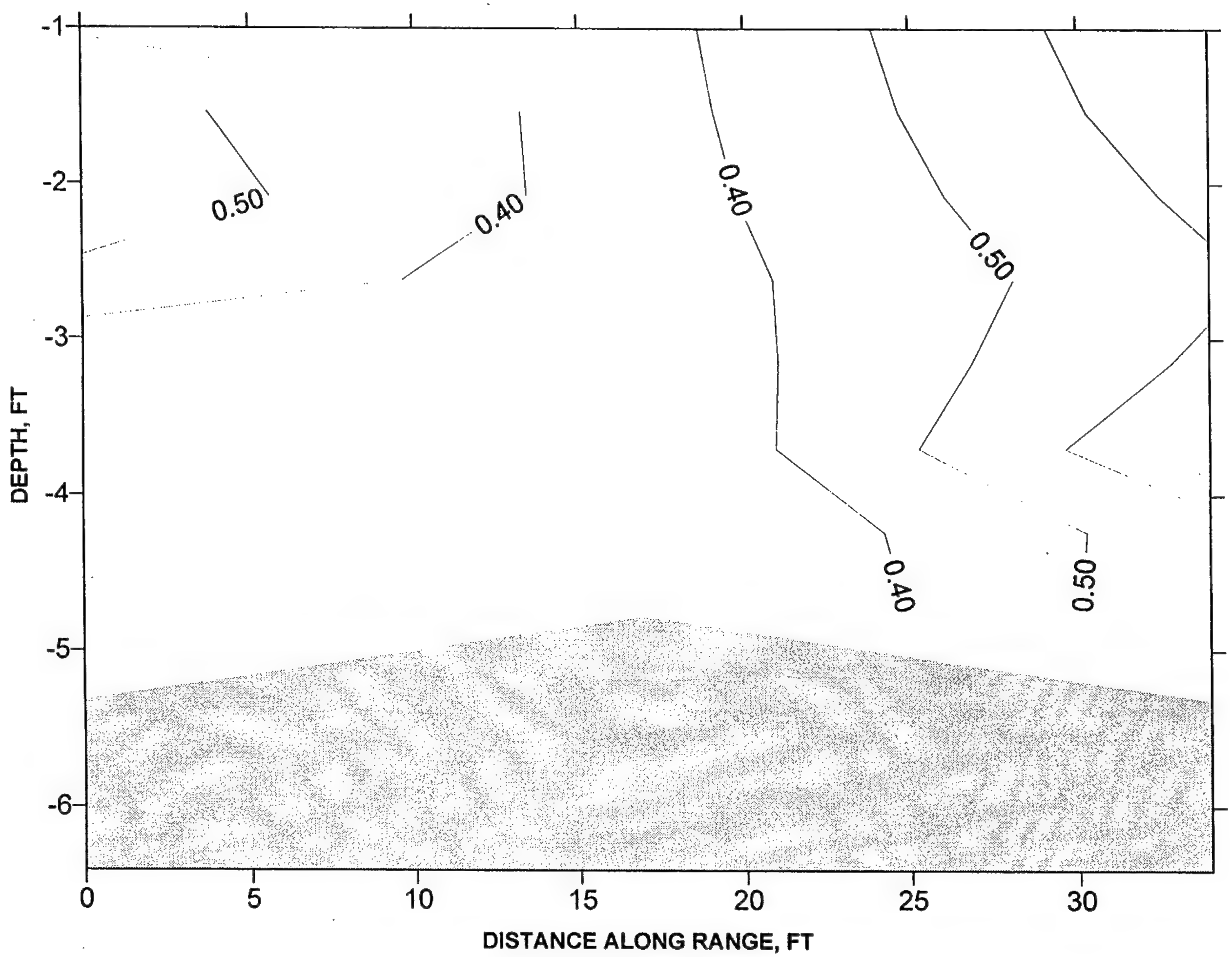
VELOCITY MAGNITUDES, FPS
Range 6 1055
18 AUGUST 1995



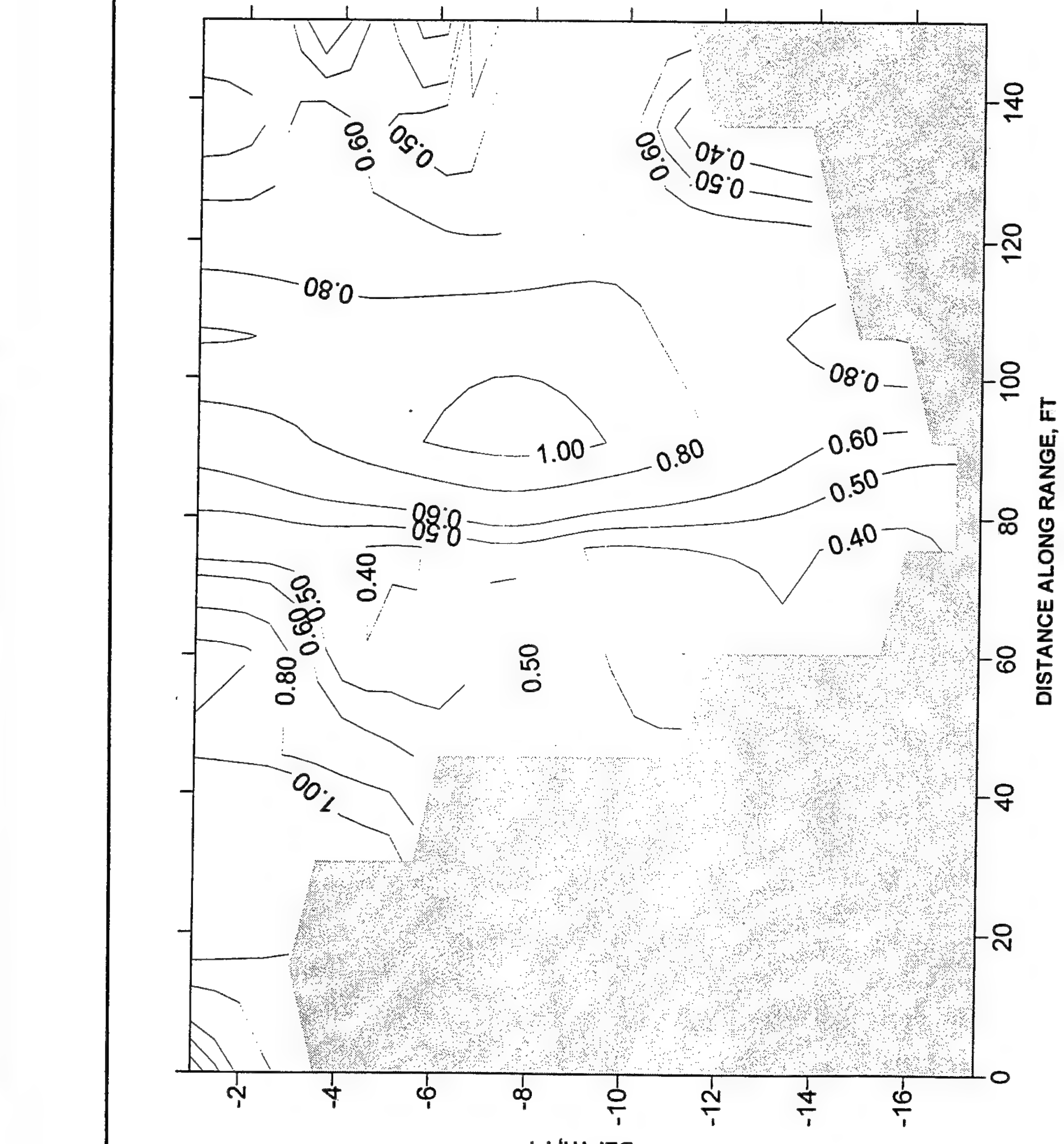
VELOCITY MAGNITUDES, FPS
Range 6 1205
18 AUGUST 1995



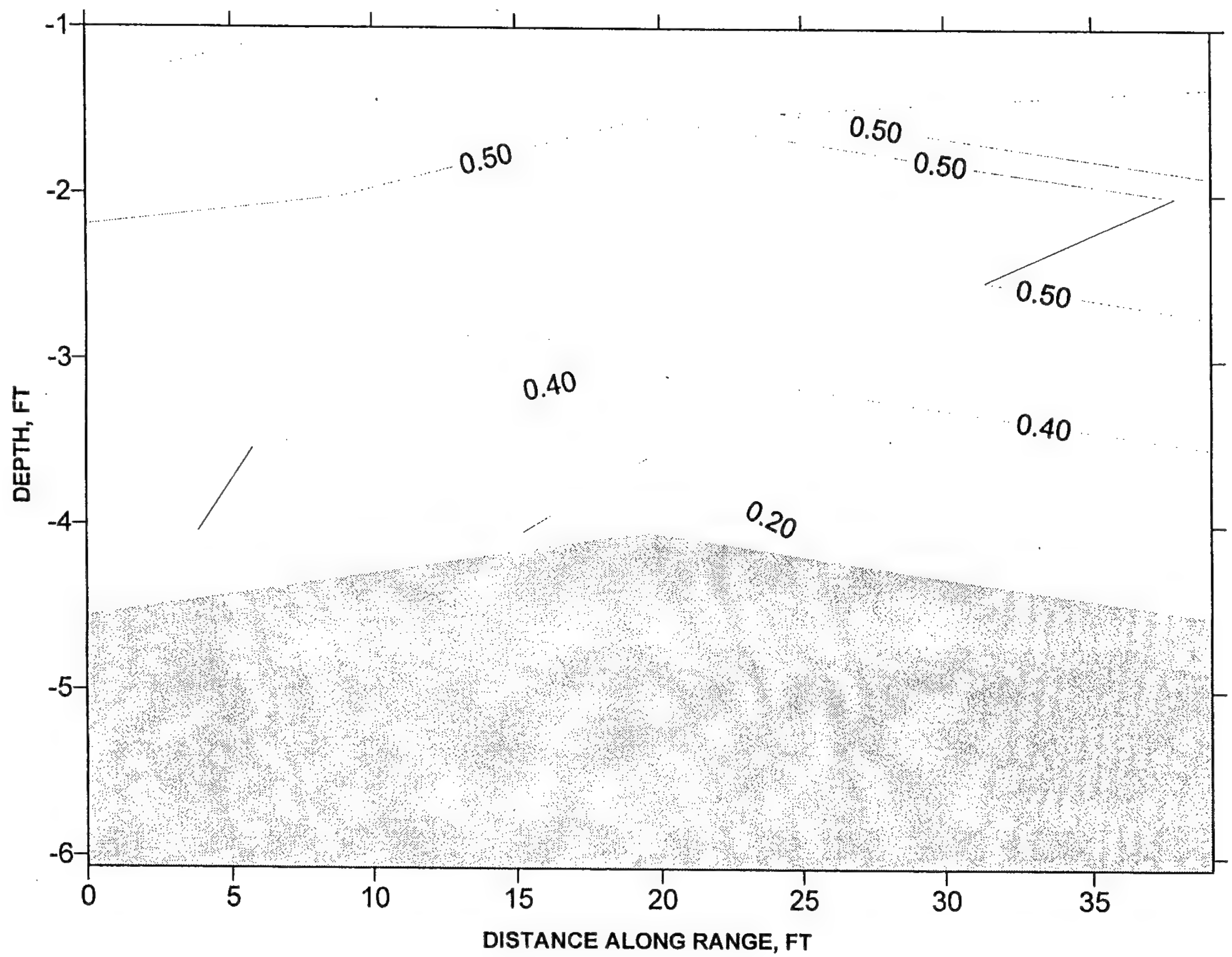
VELOCITY MAGNITUDES, FPS
Range 6 1311
18 AUGUST 1995



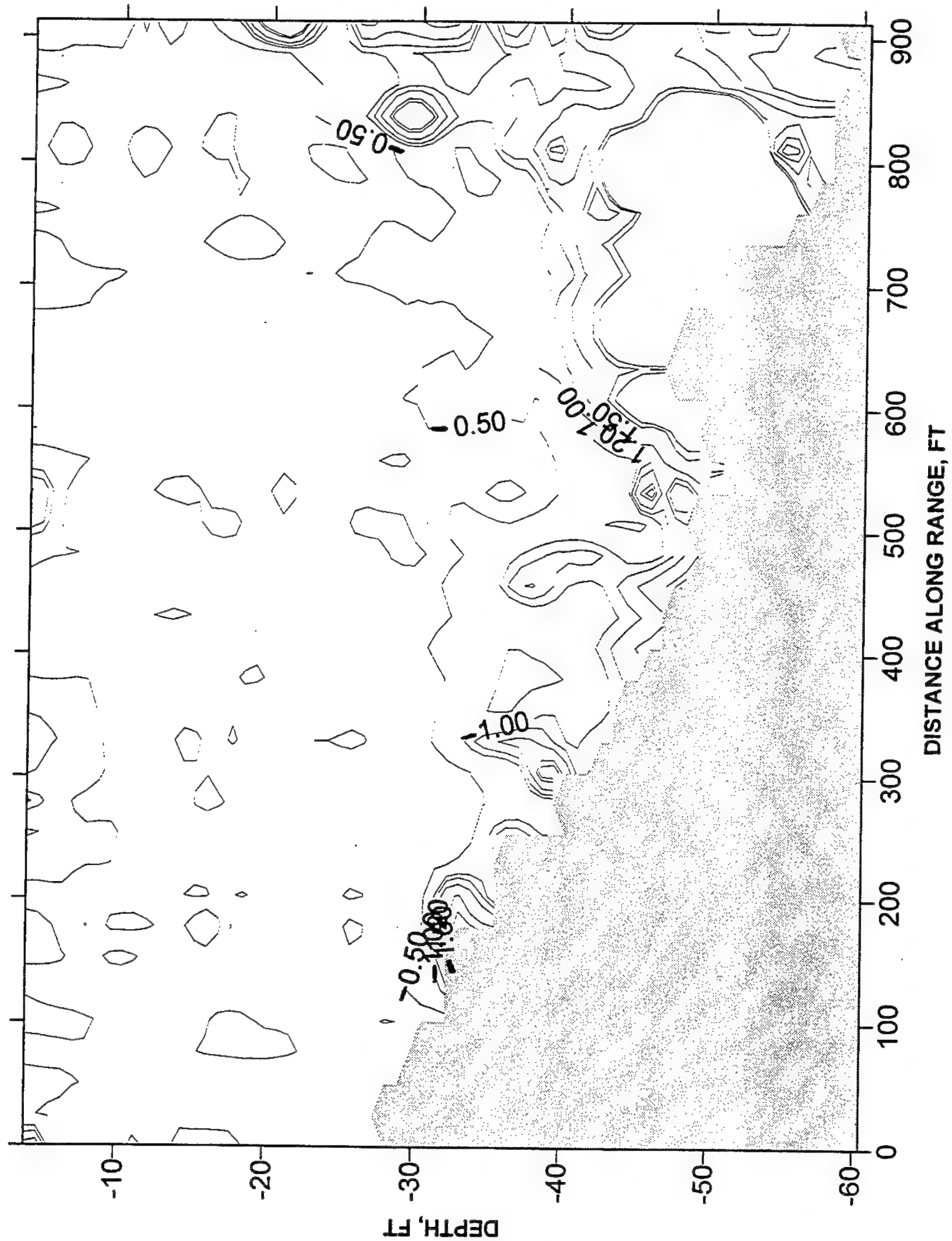
VELOCITY MAGNITUDES, FPS
Range 6 1455
18 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 6 1605
18 AUGUST 1995

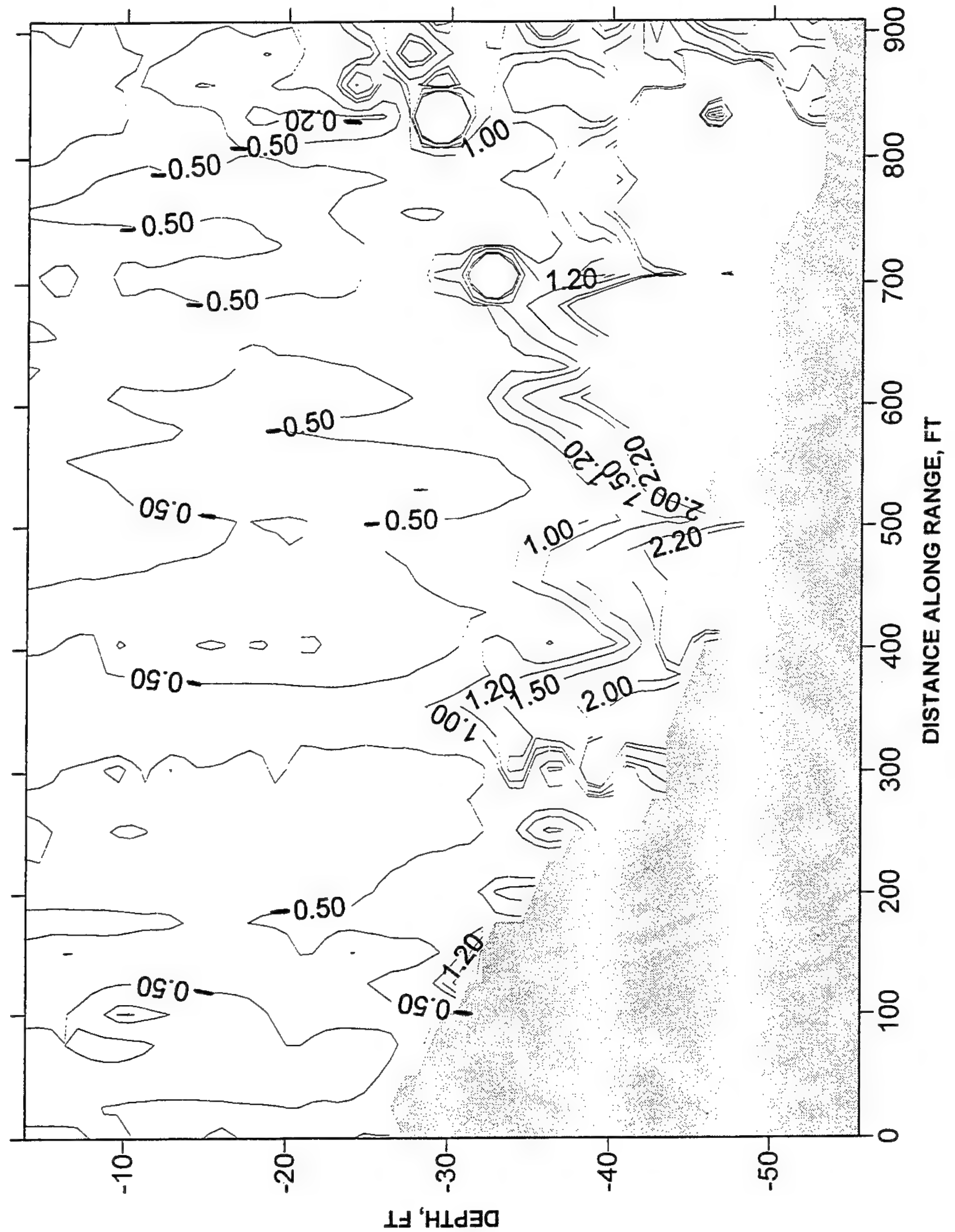


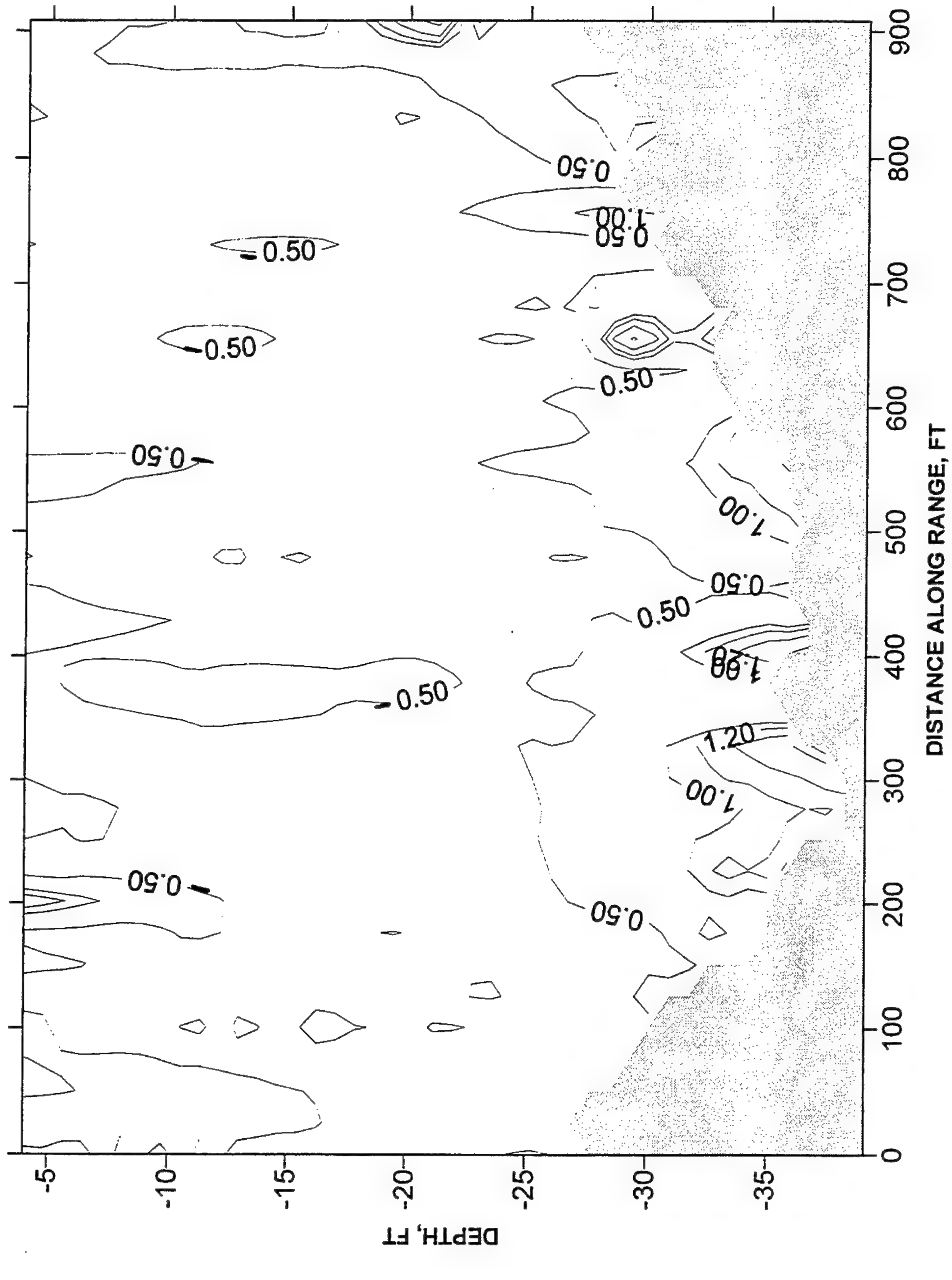
VELOCITY MAGNITUDES, FPS
Range 6 1808
18 AUGUST 1995



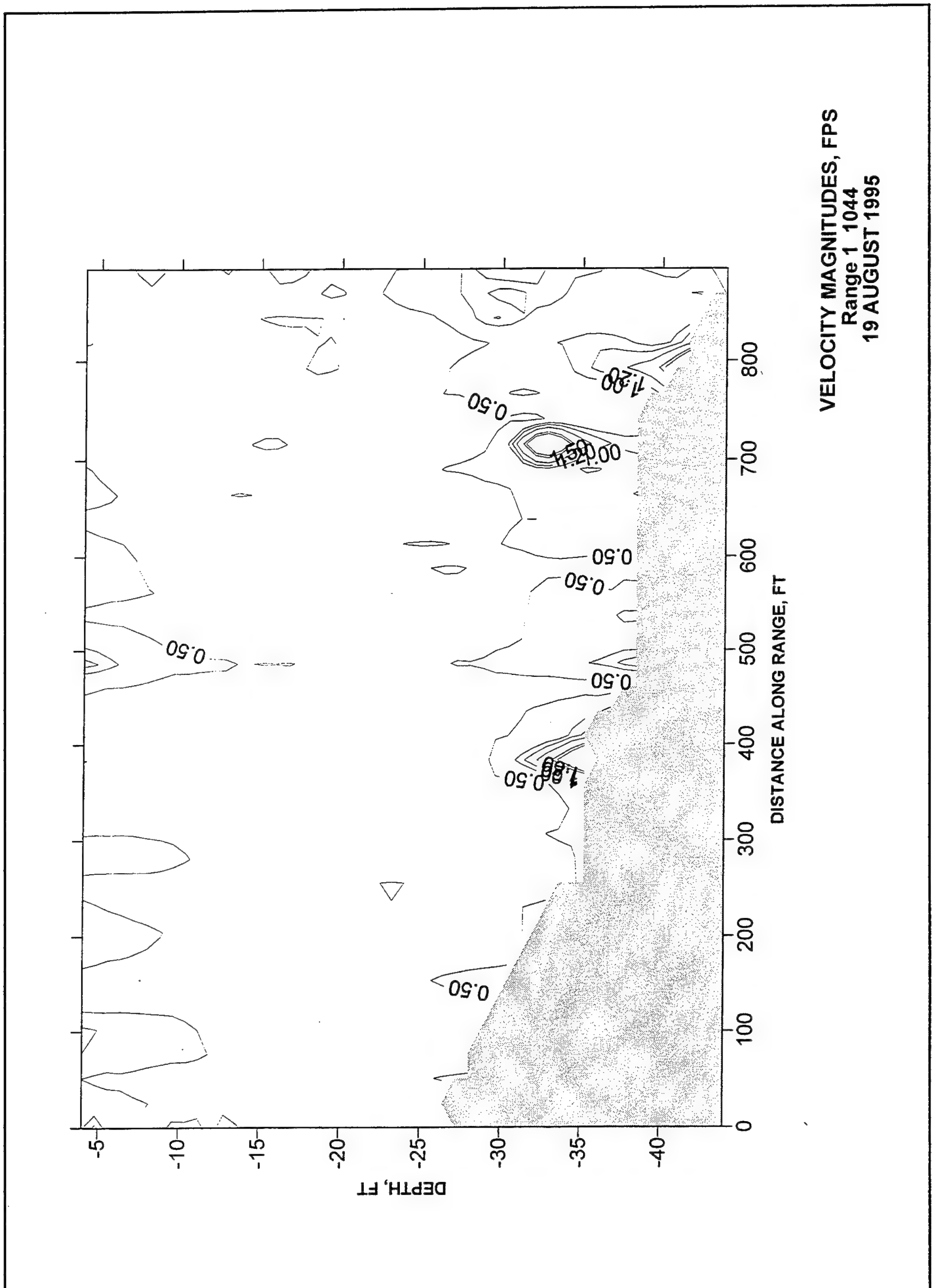
VELOCITY MAGNITUDES, FPS
Range 1 0521
19 AUGUST 1995

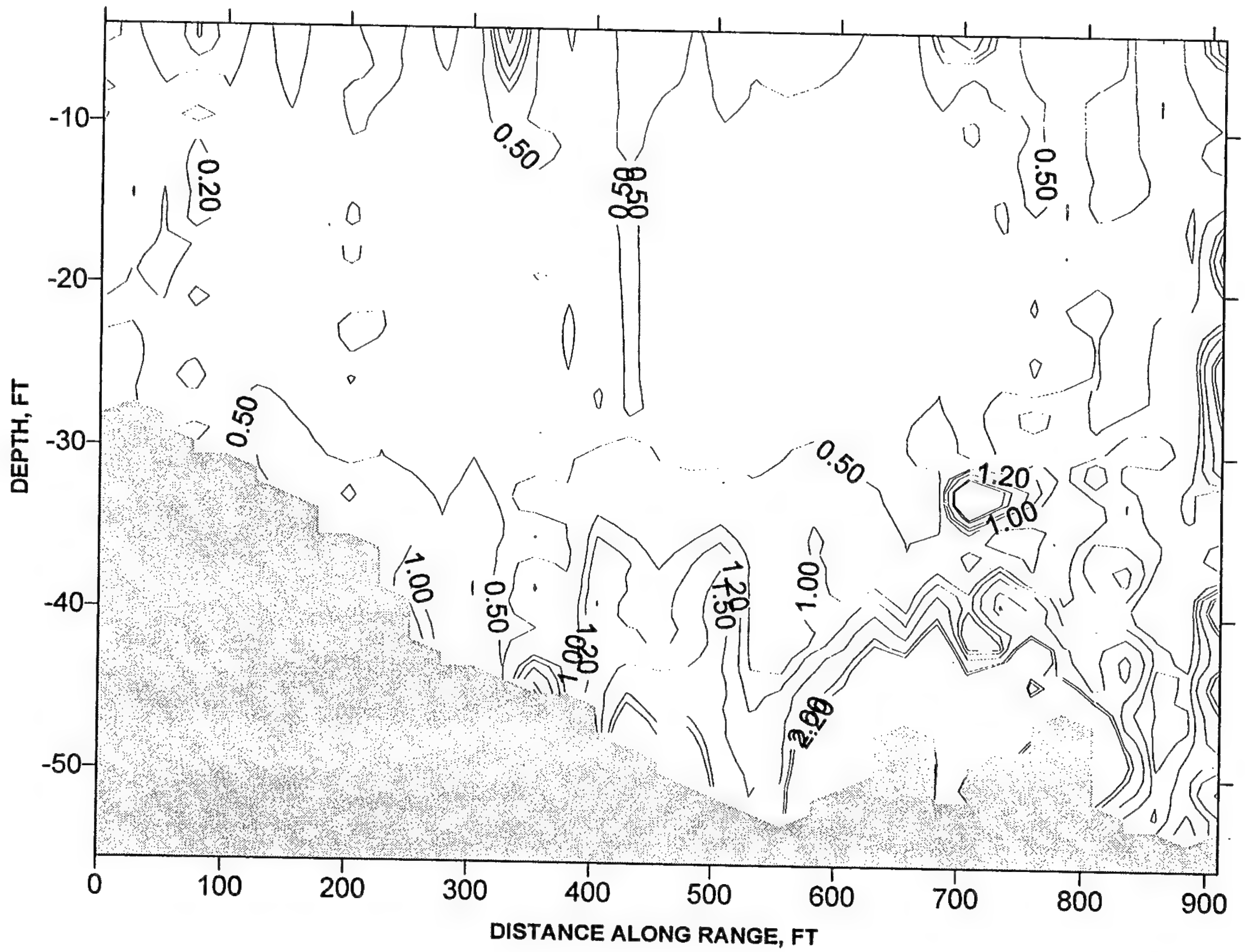
VELOCITY MAGNITUDES, FPS
Range 1 0649
19 AUGUST 1995



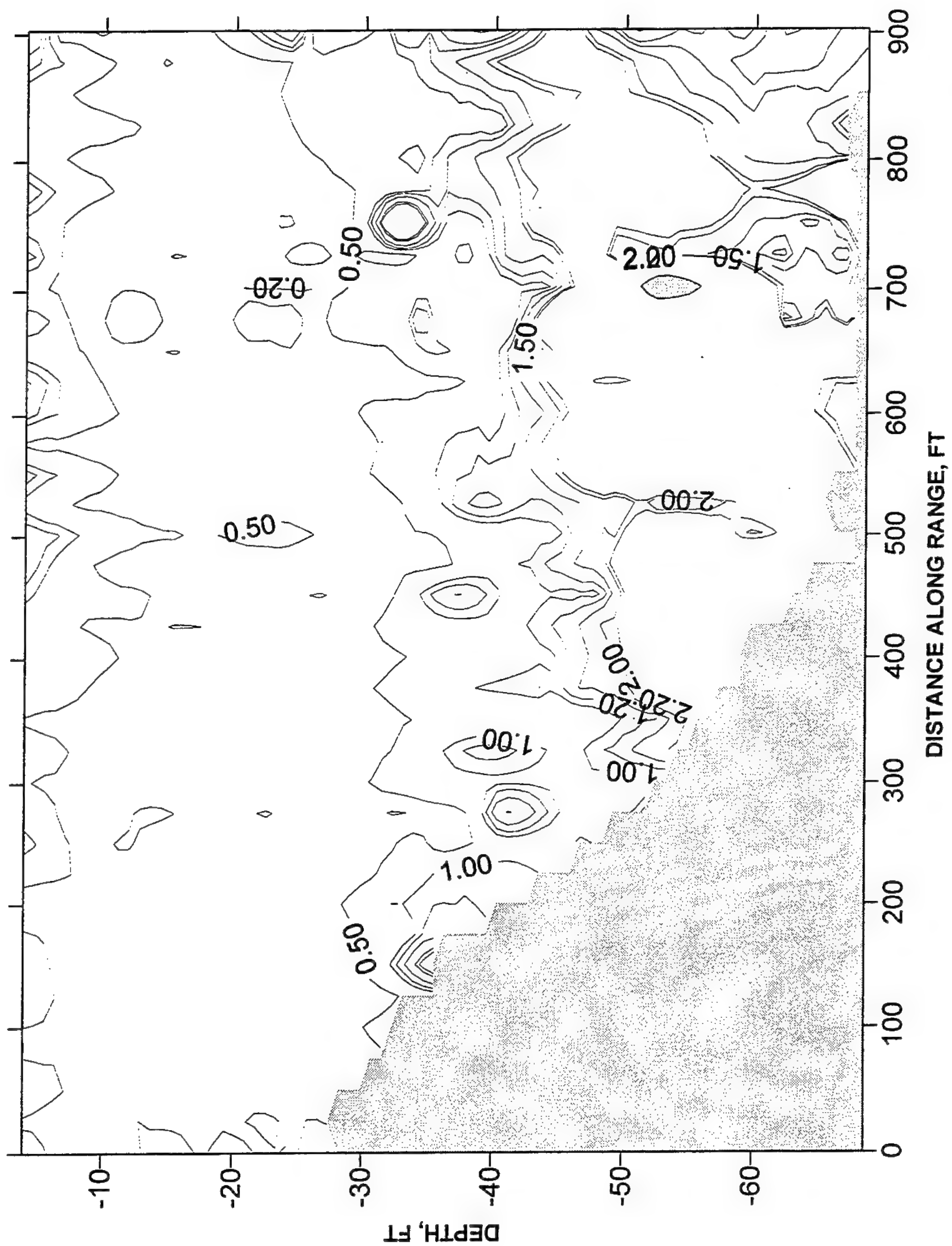


VELOCITY MAGNITUDES, FPS
Range 1 0813
19 AUGUST 1995

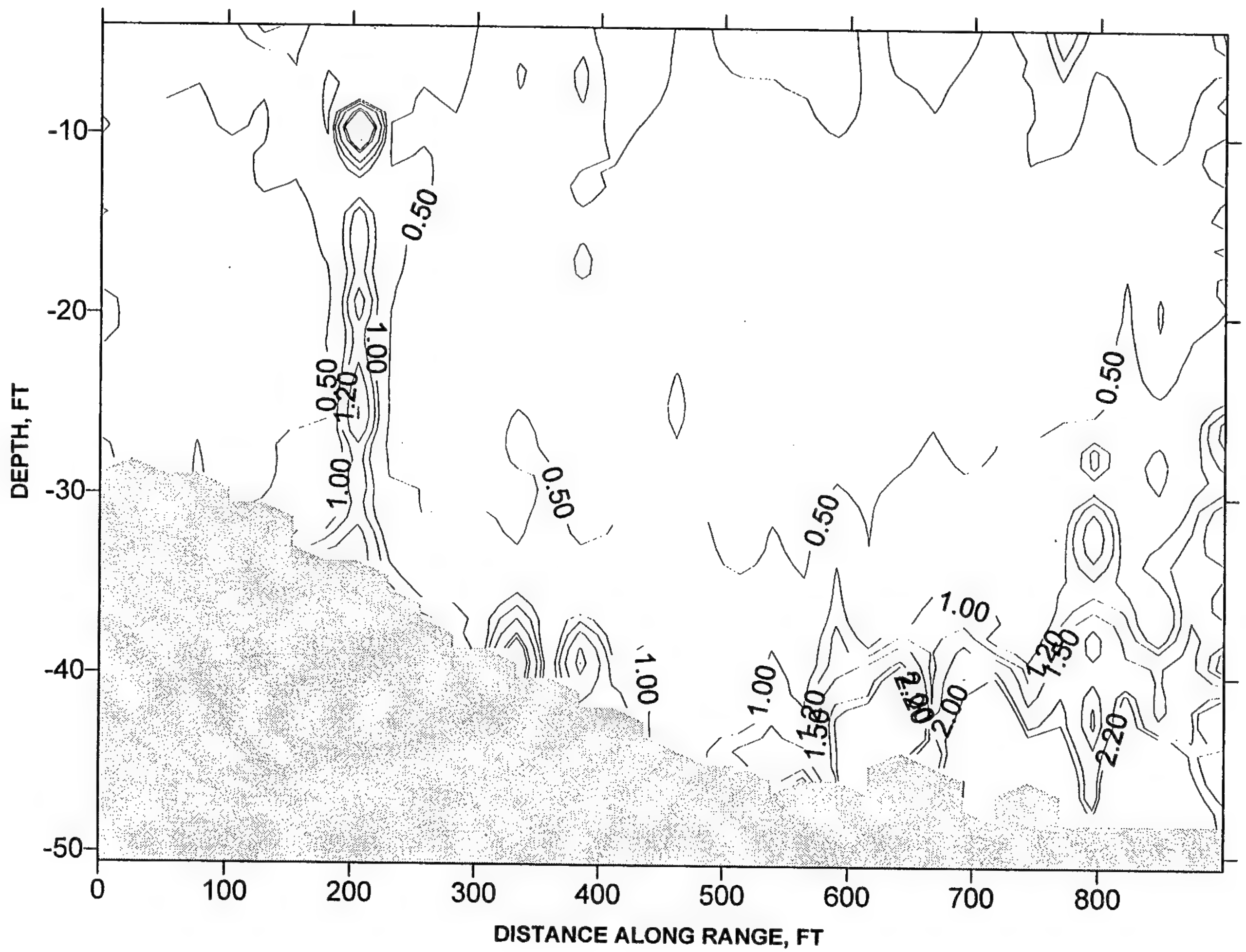

VELOCITY MAGNITUDES, FPS
Range 1 1044
19 AUGUST 1995
DEPTH, FT
DISTANCE ALONG RANGE, FT
0
100
200
300
400
500
600
700
800
-5
-10
-15
-20
-25
-30
-35
-40
0.50
1.00
1.20
1.50
1.80



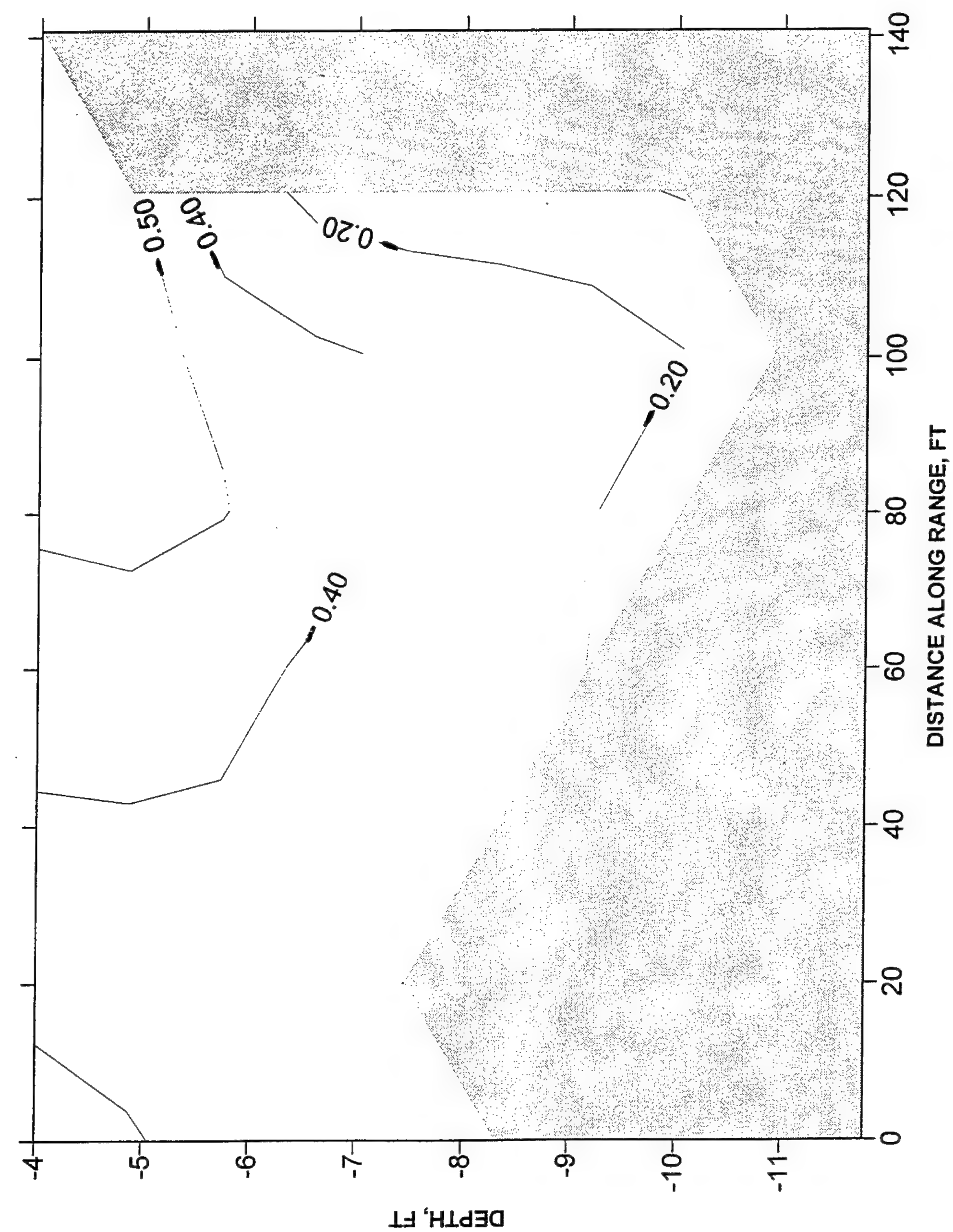
VELOCITY MAGNITUDES, FPS
Range 1 1211
19 AUGUST 1995



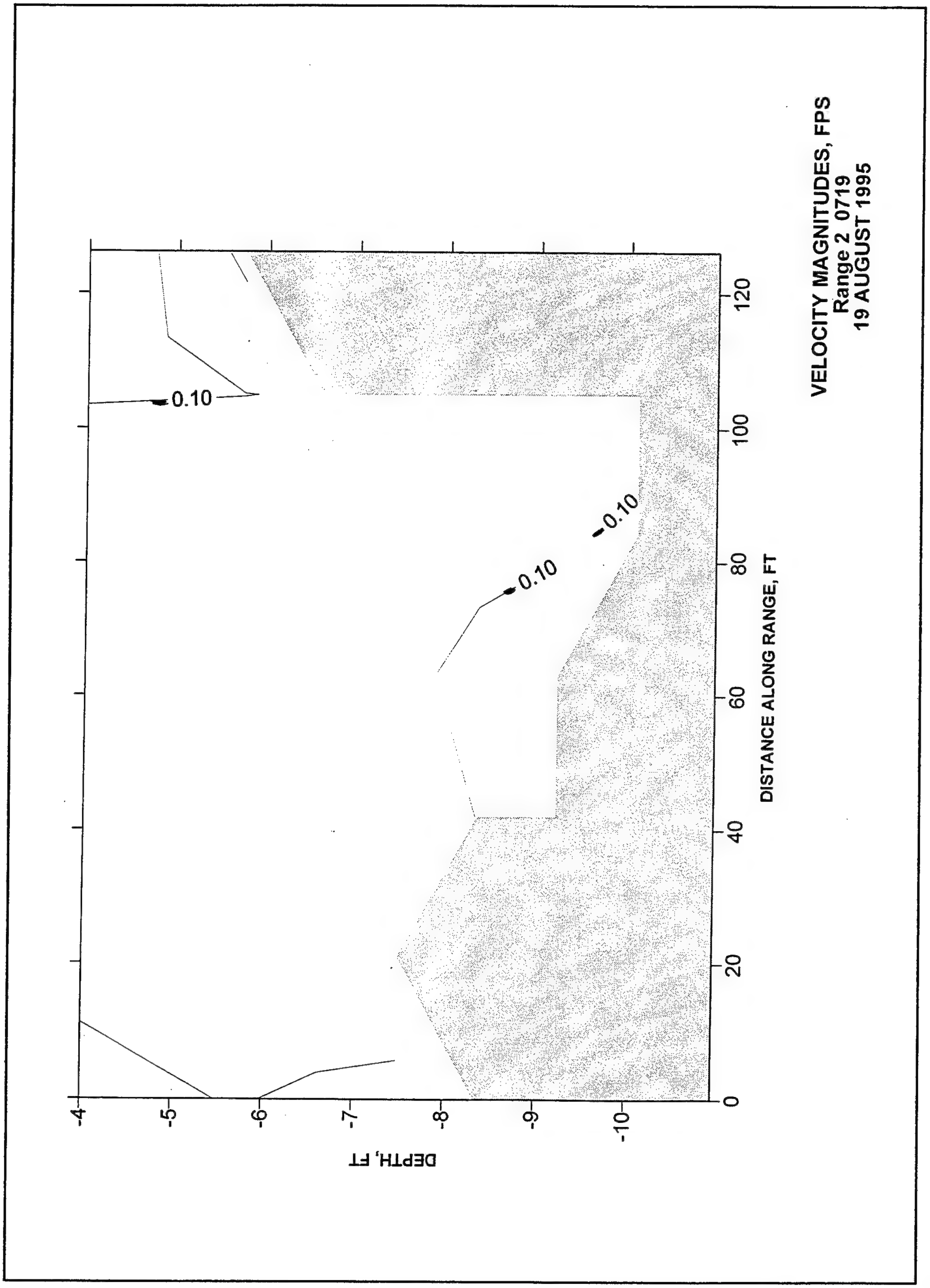
VELOCITY MAGNITUDES, FPS
Range 1 1443
19 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 1 1557
19 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 2 0551
19 AUGUST 1995


VELOCITY MAGNITUDES, FPS
Range 2 0719
19 AUGUST 1995
DEPTH, FT
DISTANCE ALONG RANGE, FT
-4
-5
-6
-7
-8
-9
-10
0
20
40
60
80
100
120
0.10
0.10
0.10

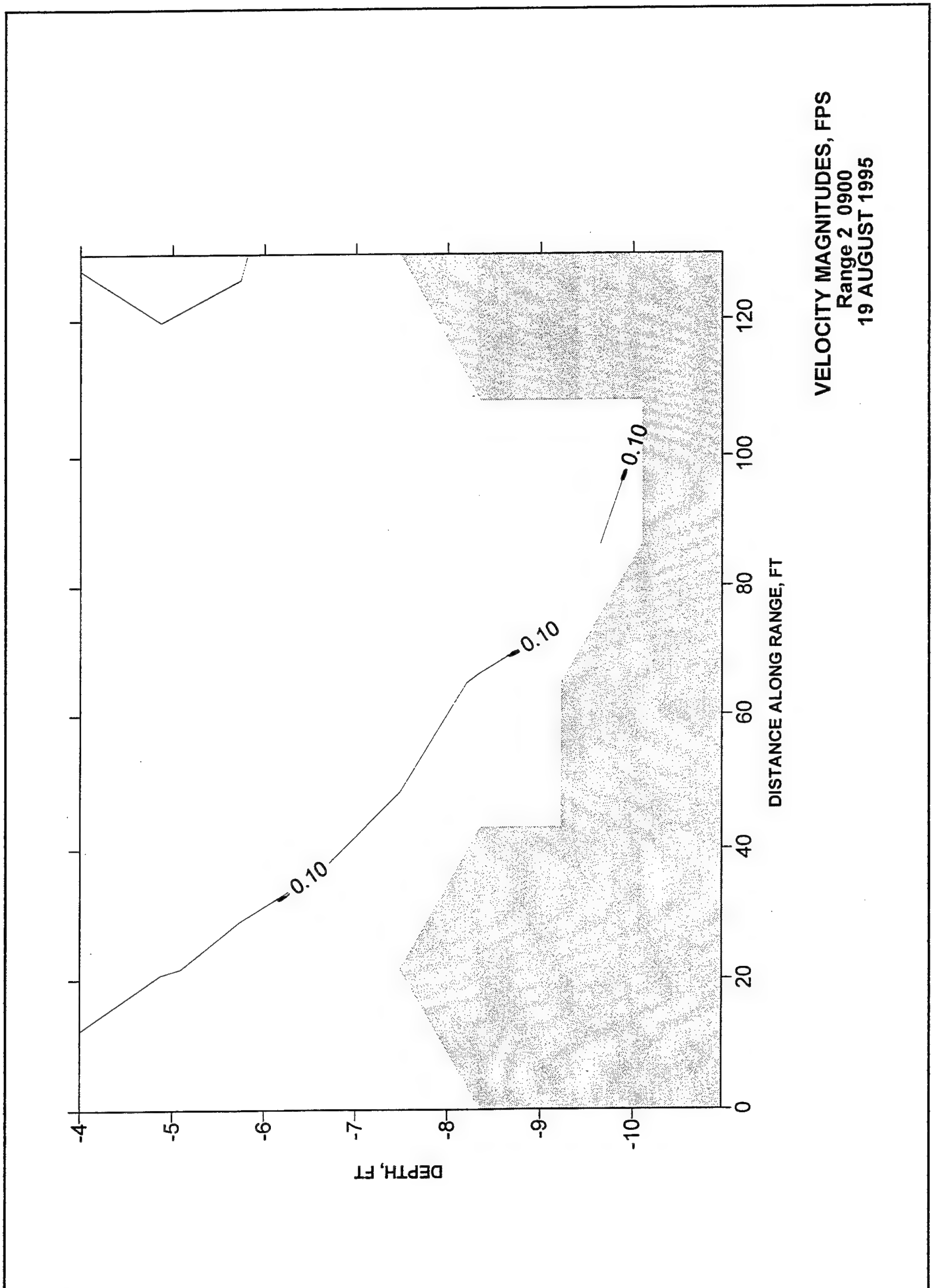
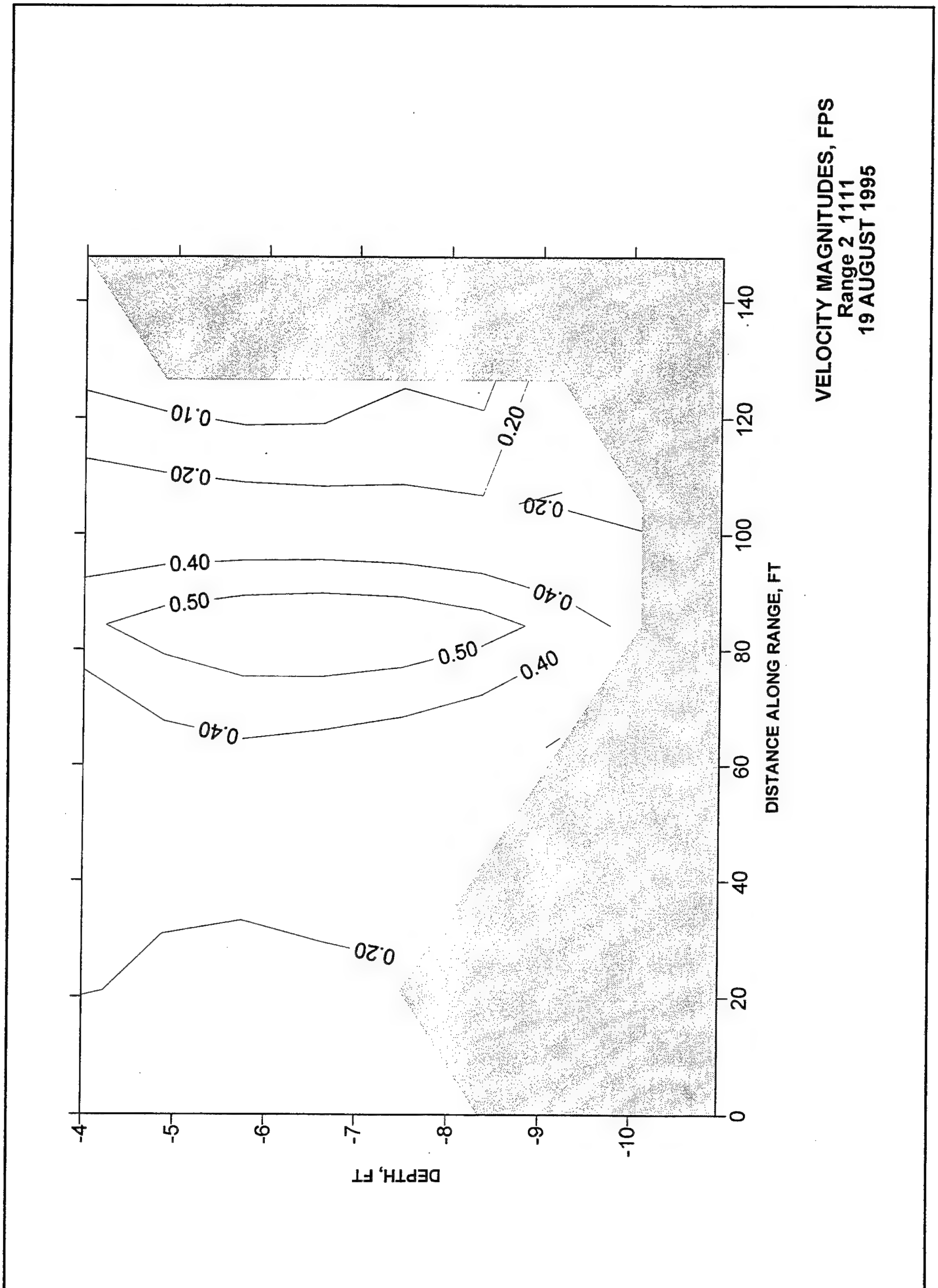

VELOCITY MAGNITUDES, FPS
Range 2 0900
19 AUGUST 1995
DEPTH, FT
-4
-5
-6
-7
-8
-9
-10
DISTANCE ALONG RANGE, FT
0
20
40
60
80
100
120
0.10
0.10
0.10

Plate 114


VELOCITY MAGNITUDES, FPS
Range 2 1111
19 AUGUST 1995
DISTANCE ALONG RANGE, FT
DEPTH, FT
0
20
40
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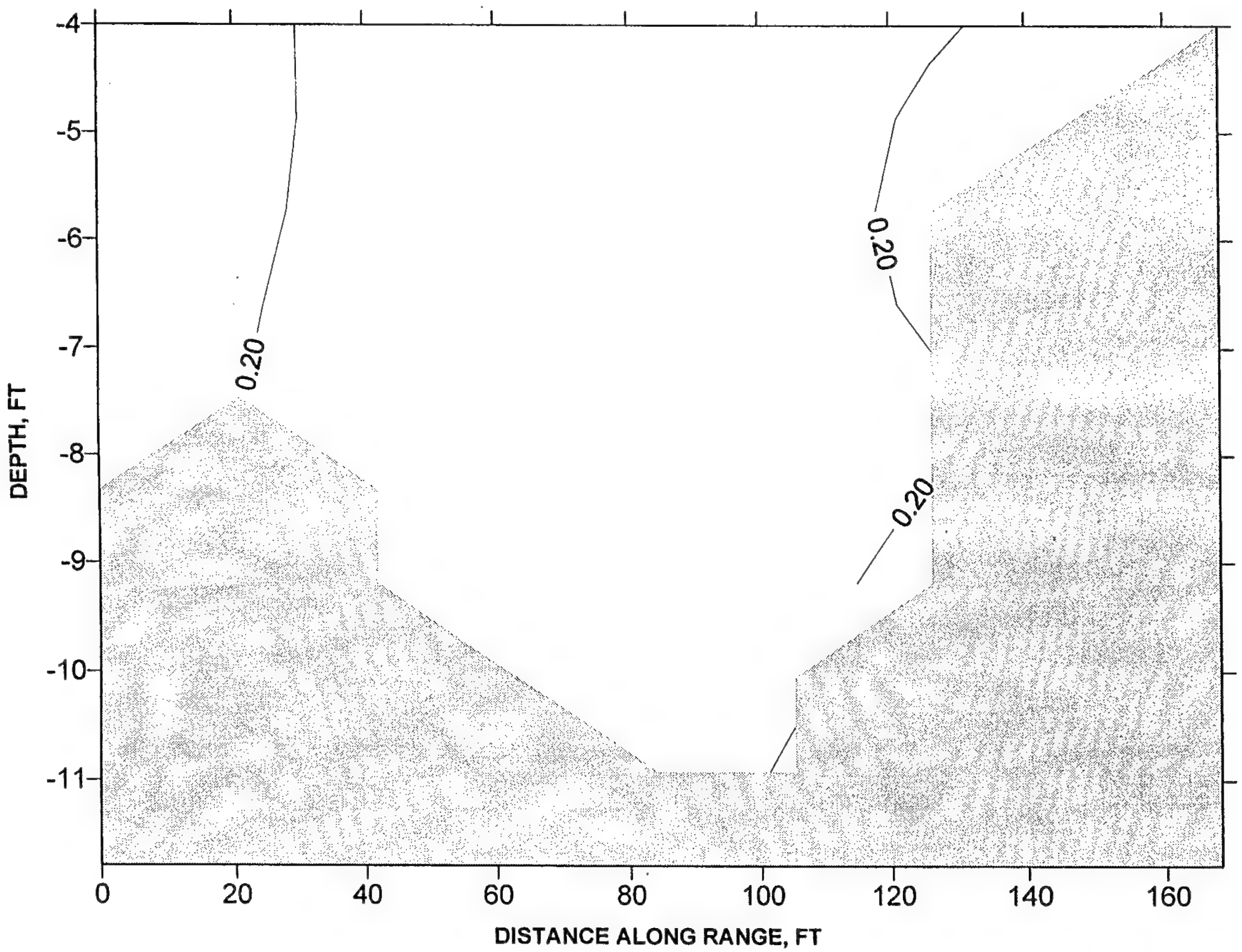
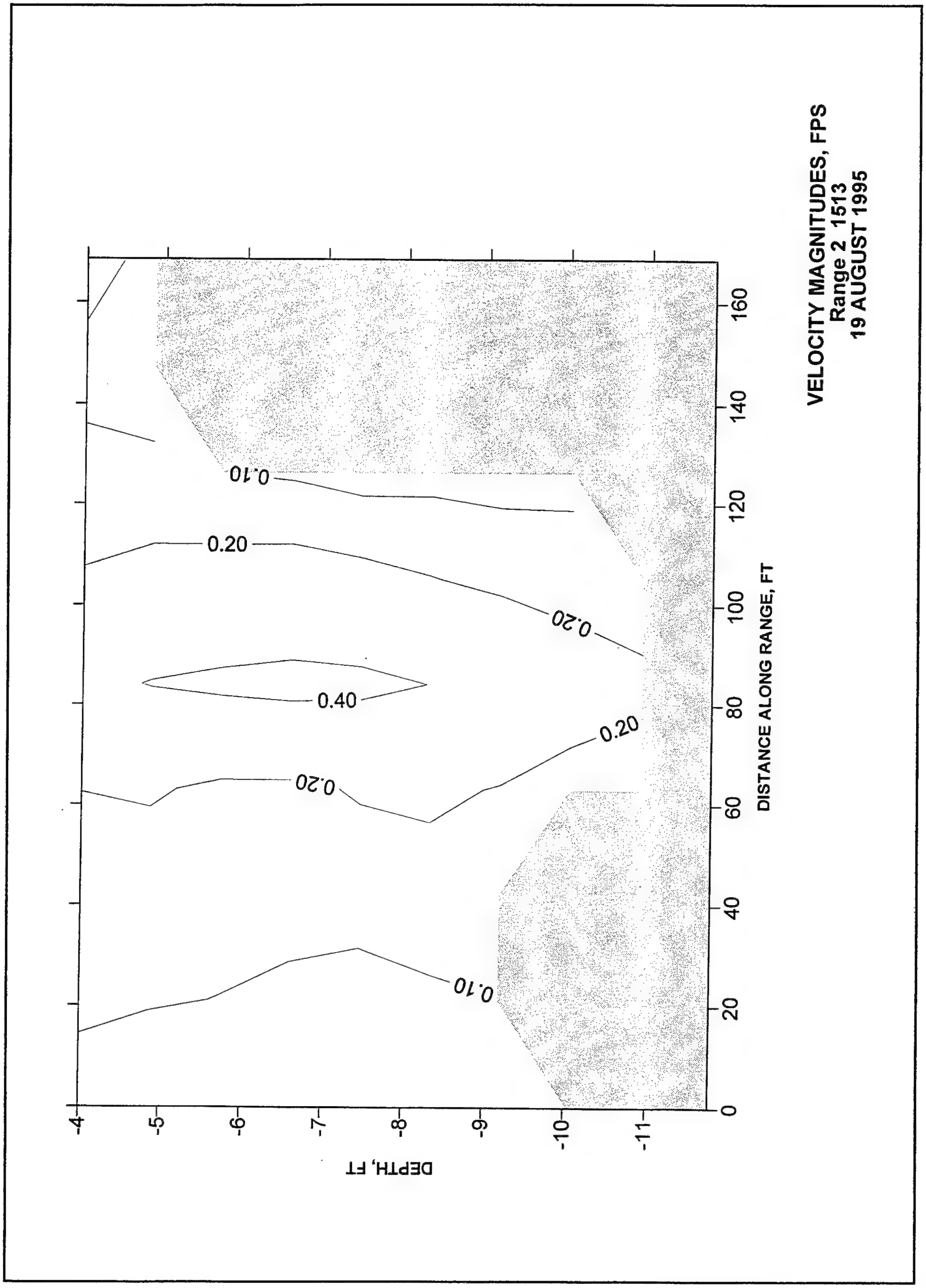
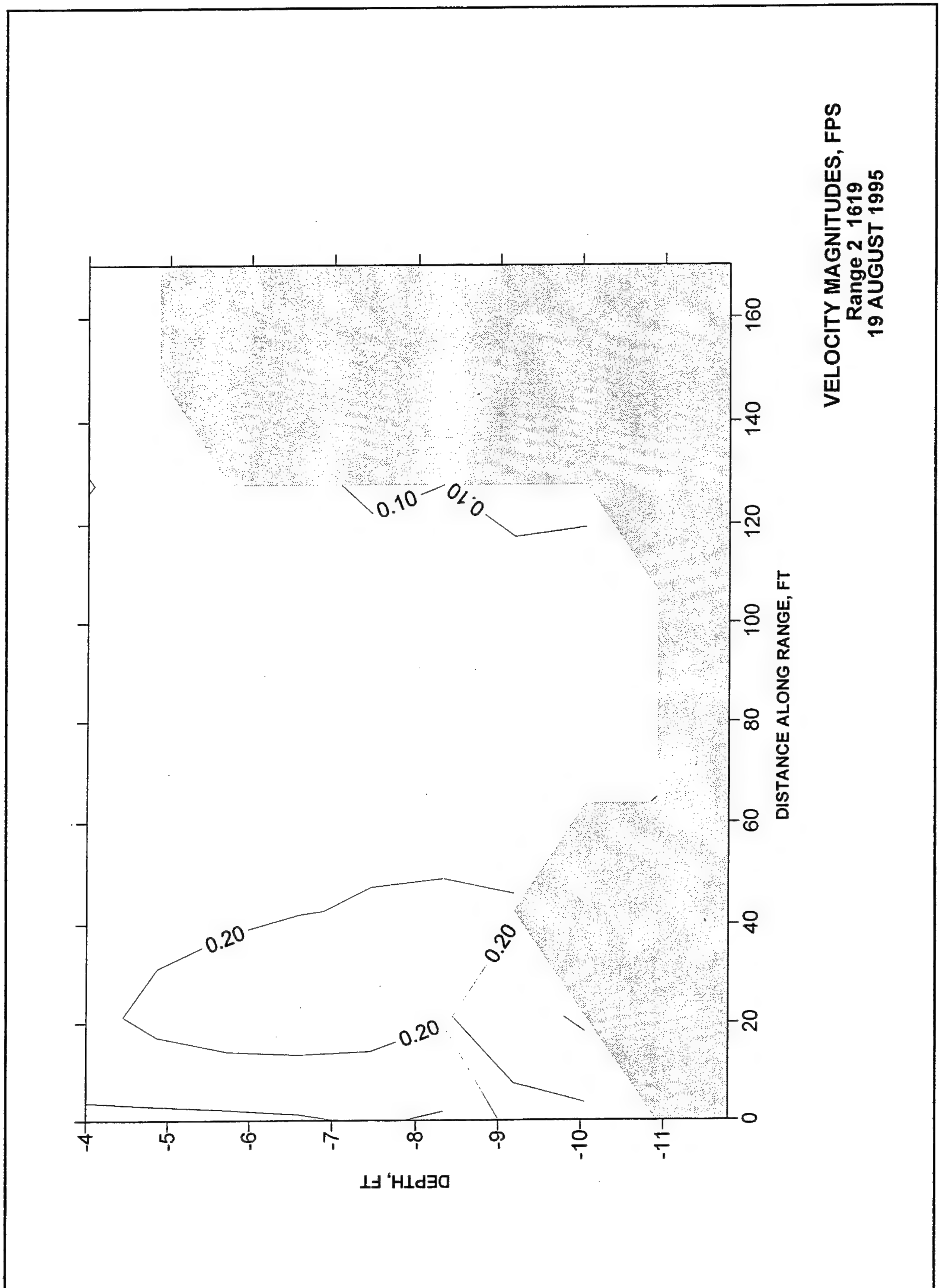
80
100
120
140
-4
-5
-6
-7
-8
-9
-10
0.10
0.20
0.40
0.50



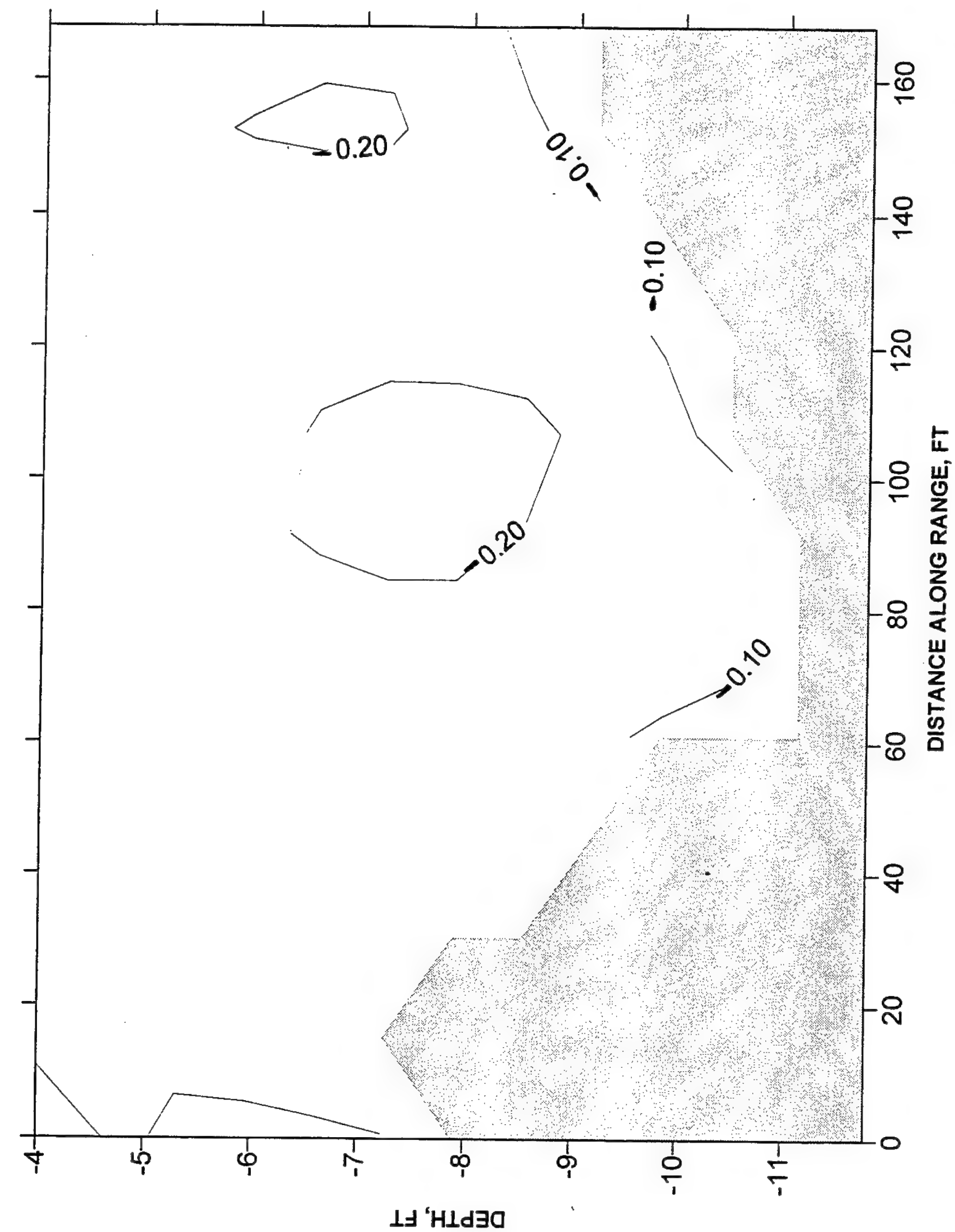
VELOCITY MAGNITUDES, FPS
Range 2 1322
19 AUGUST 1995


VELOCITY MAGNITUDES, FPS
Range 2 1513
19 AUGUST 1995
DEPTH, FT
DISTANCE ALONG RANGE, FT
-4
-5
-6
-7
-8
-9
-10
-11
0
20
40
60
80
100
120
140
160
0.10
0.20
0.40
0.20
0.20
0.20
0.10

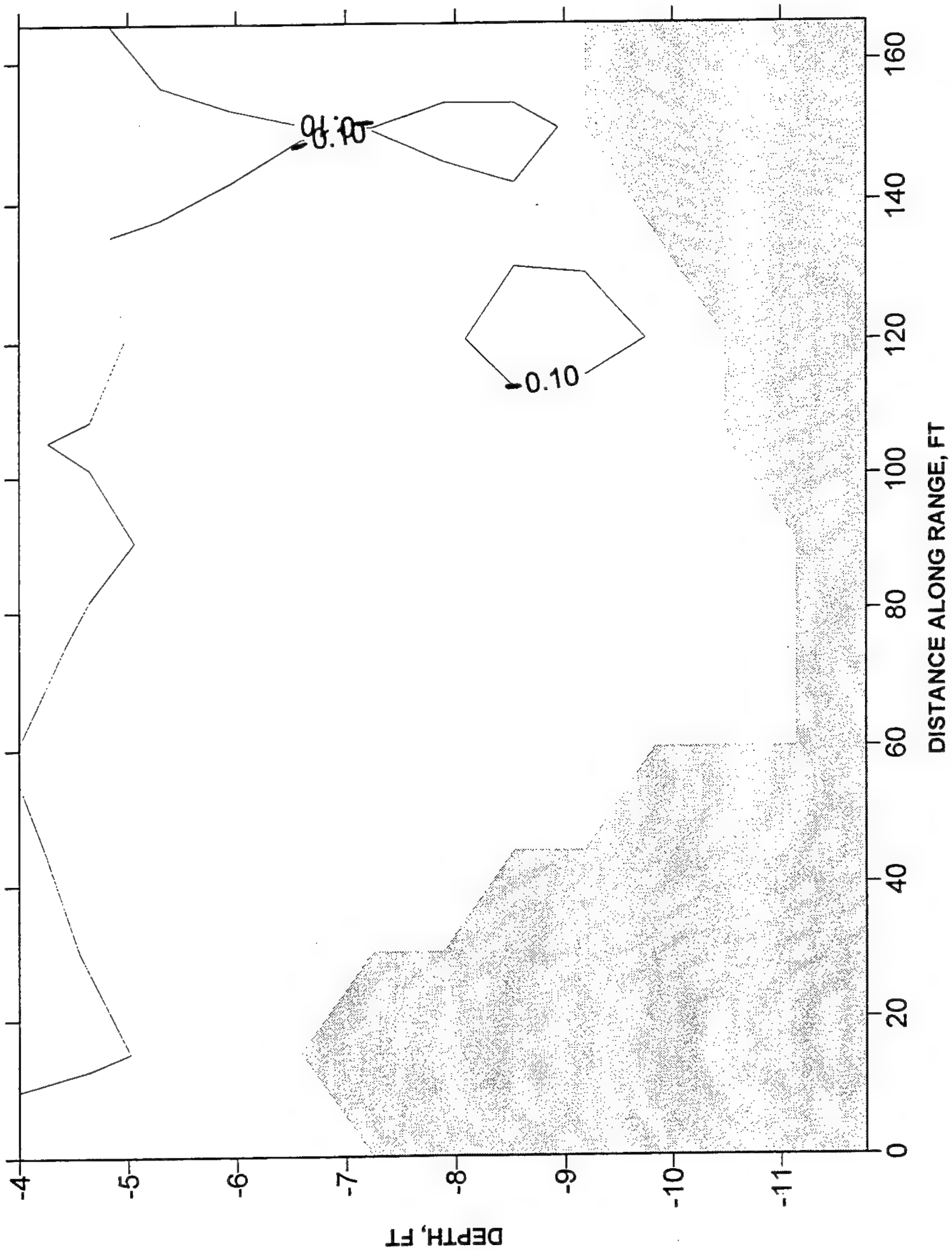


VELOCITY MAGNITUDES, FPS
Range 2 1619
19 AUGUST 1995
DISTANCE ALONG RANGE, FT
0
20
40
60
80
100
120
140
160
DEPTH, FT
-4
-5
-6
-7
-8
-9
-10
-11
0.20
0.20
0.20
0.10
0.10

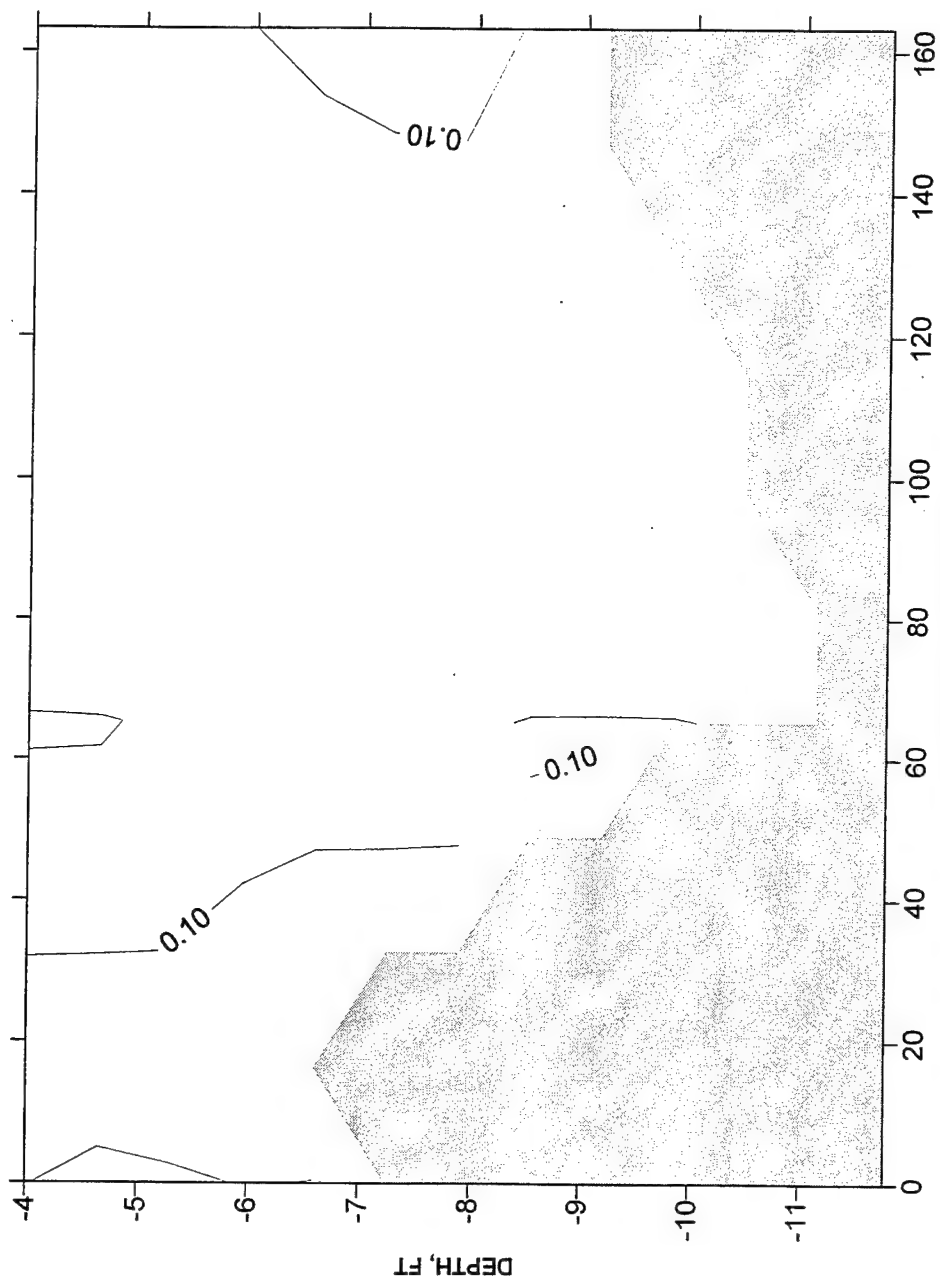
Plate 118



VELOCITY MAGNITUDES, FPS
Range 3 0614
19 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 3 0739
19 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 3 0922
19 AUGUST 1995

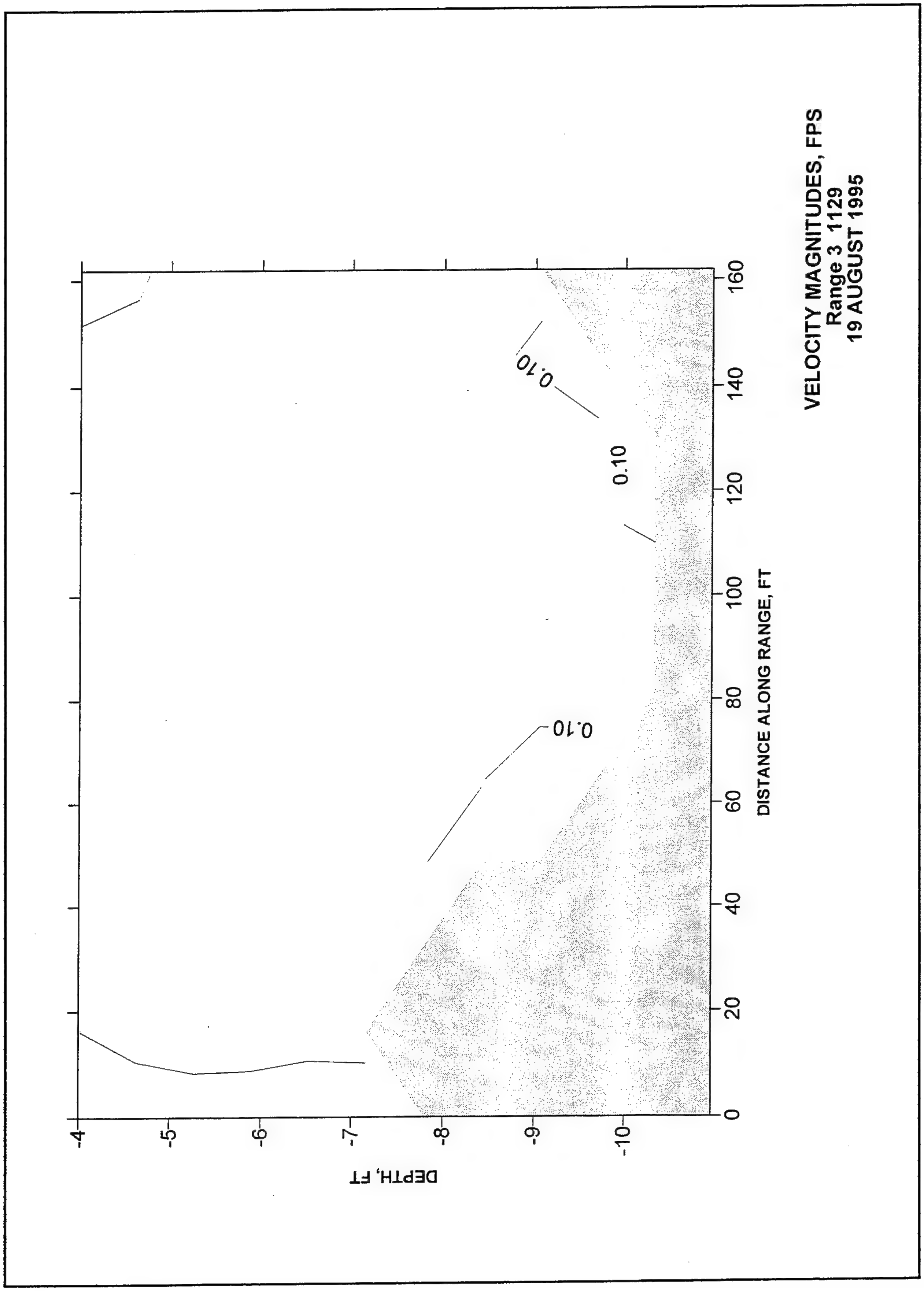
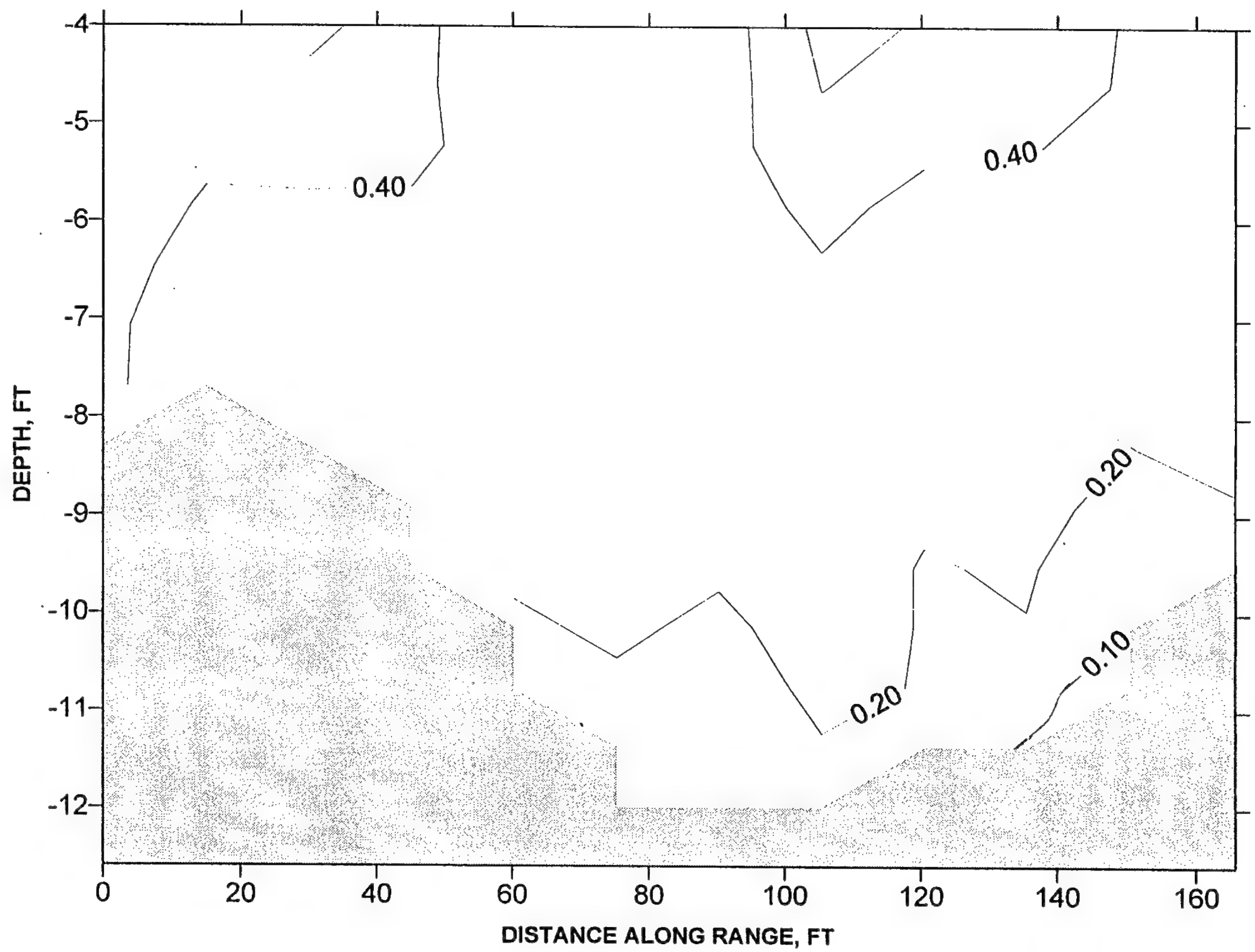
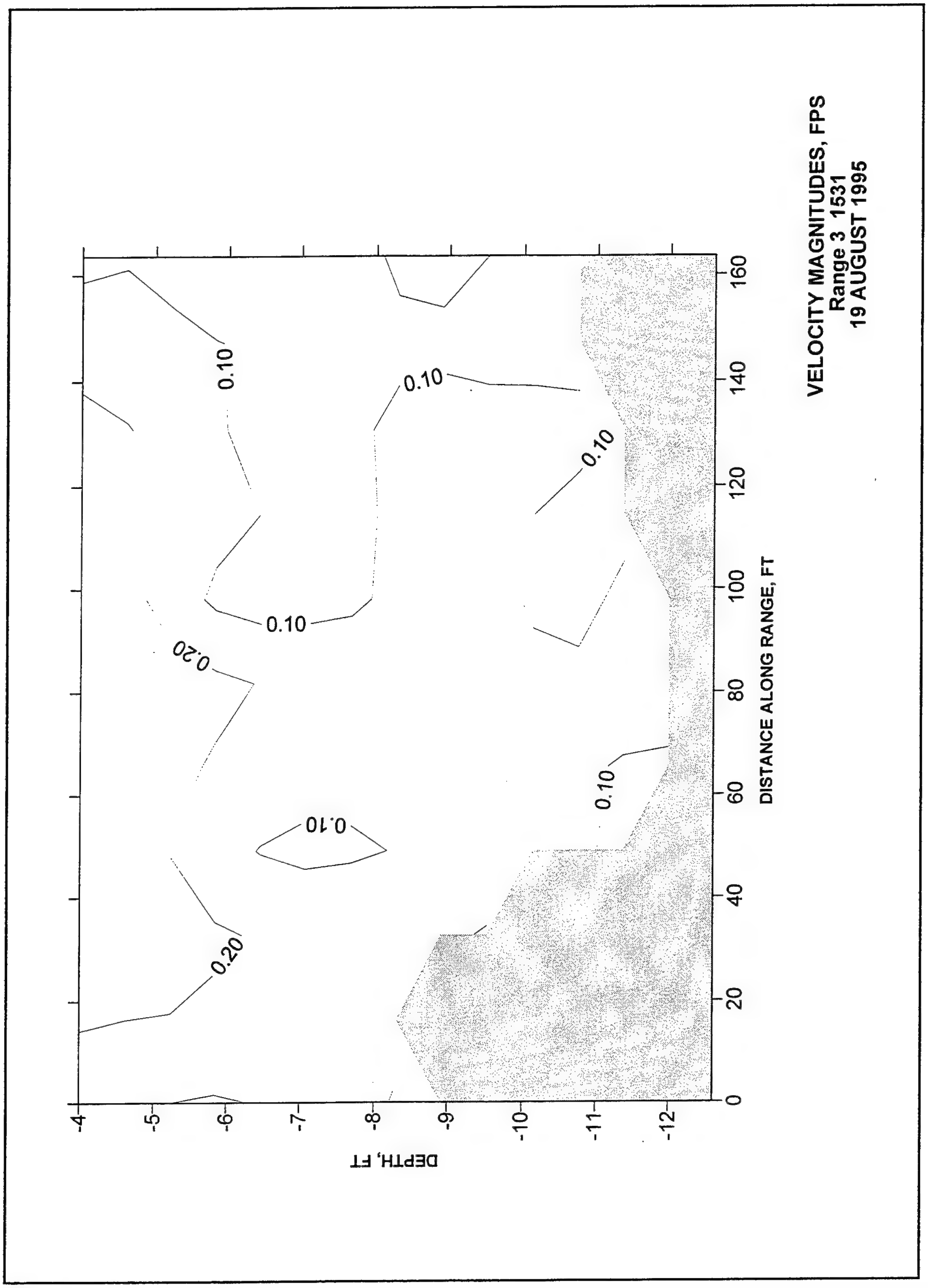

VELOCITY MAGNITUDES, FPS
Range 3 1129
19 AUGUST 1995
DISTANCE ALONG RANGE, FT
DEPTH, FT
0.10
0.10
0.10
0
20
40
60
80
100
120
140
160
-4
-5
-6
-7
-8
-9
-10

Plate 122



VELOCITY MAGNITUDES, FPS
Range 3 1341
19 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 3 1531
19 AUGUST 1995
DISTANCE ALONG RANGE, FT
DEPTH, FT
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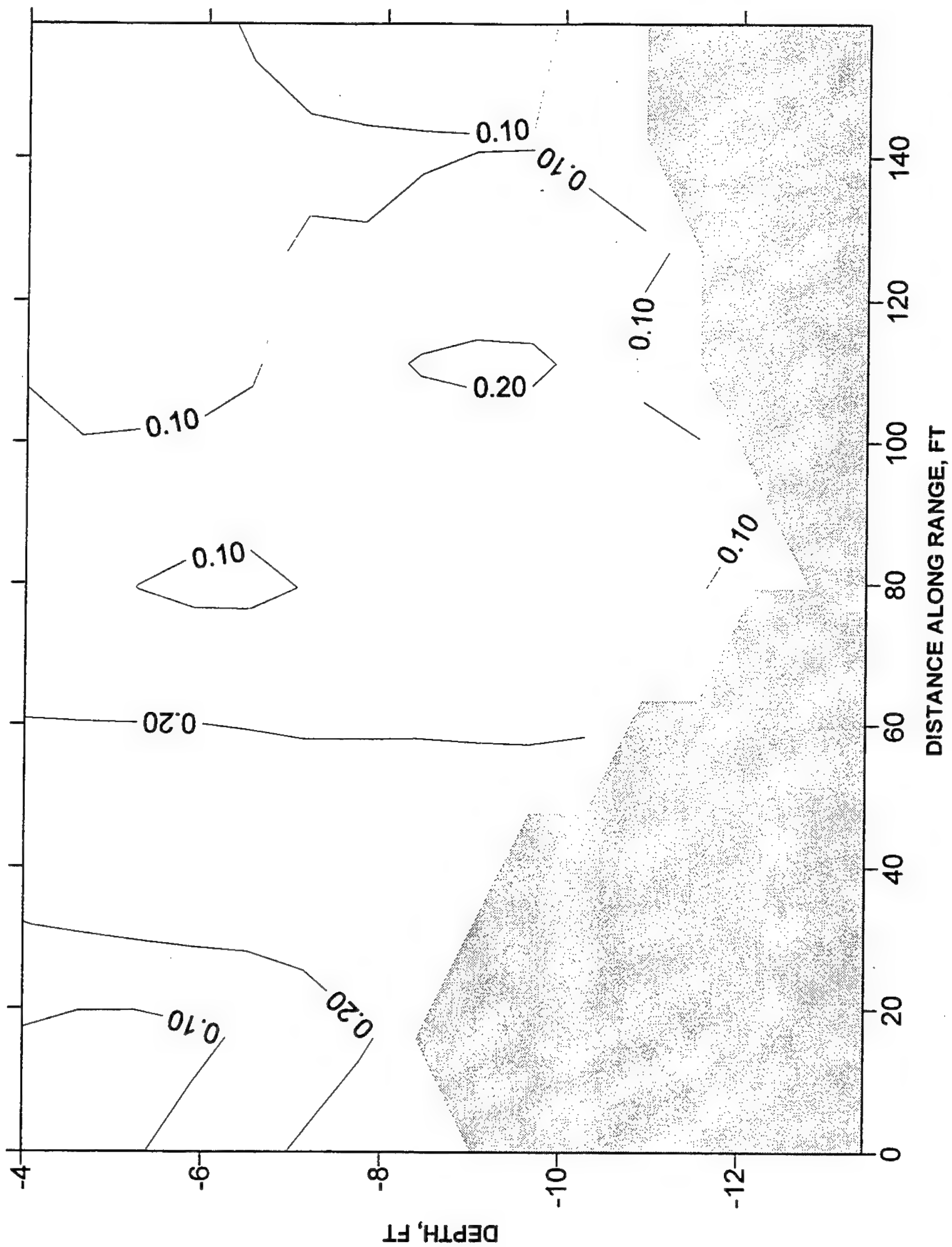
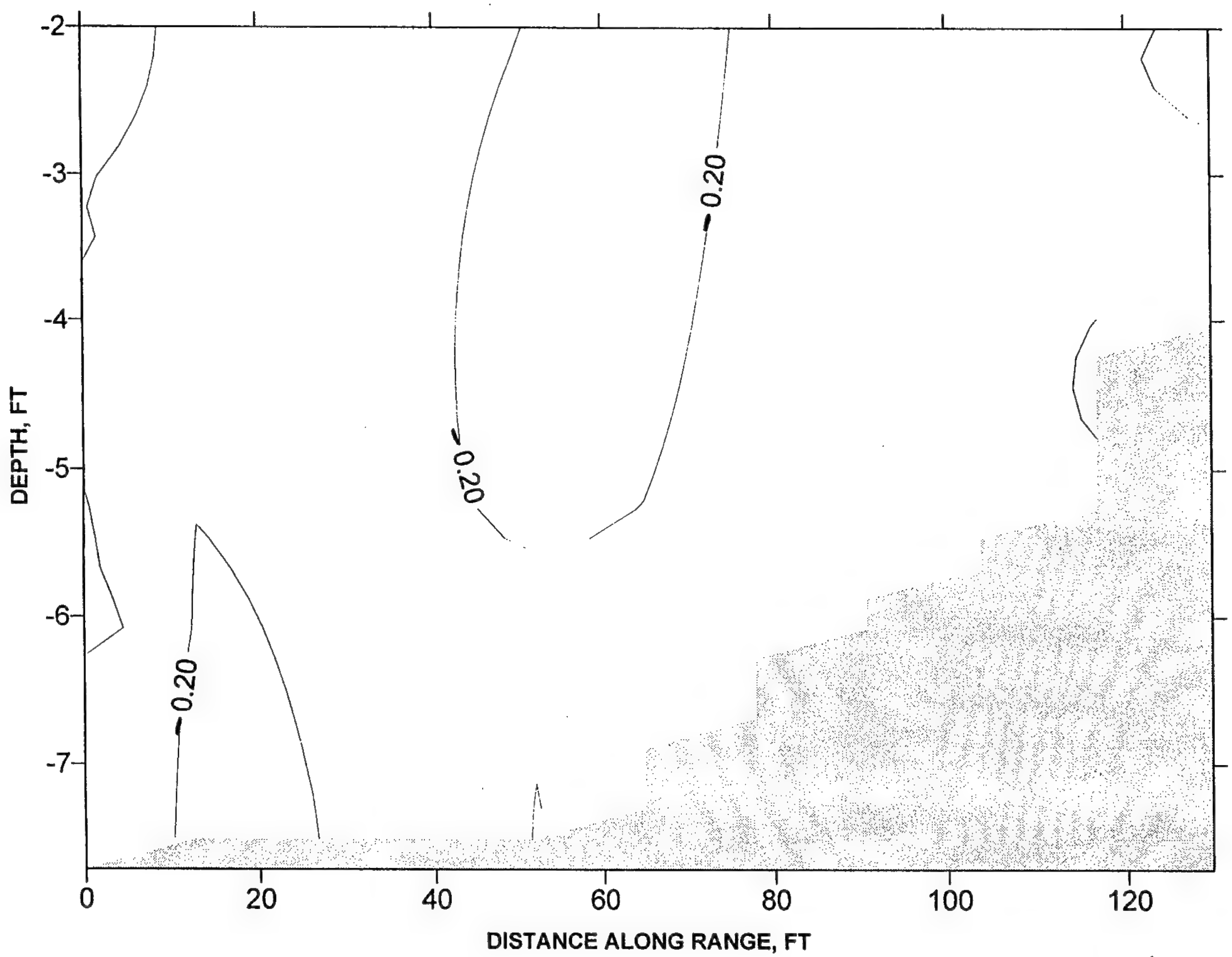
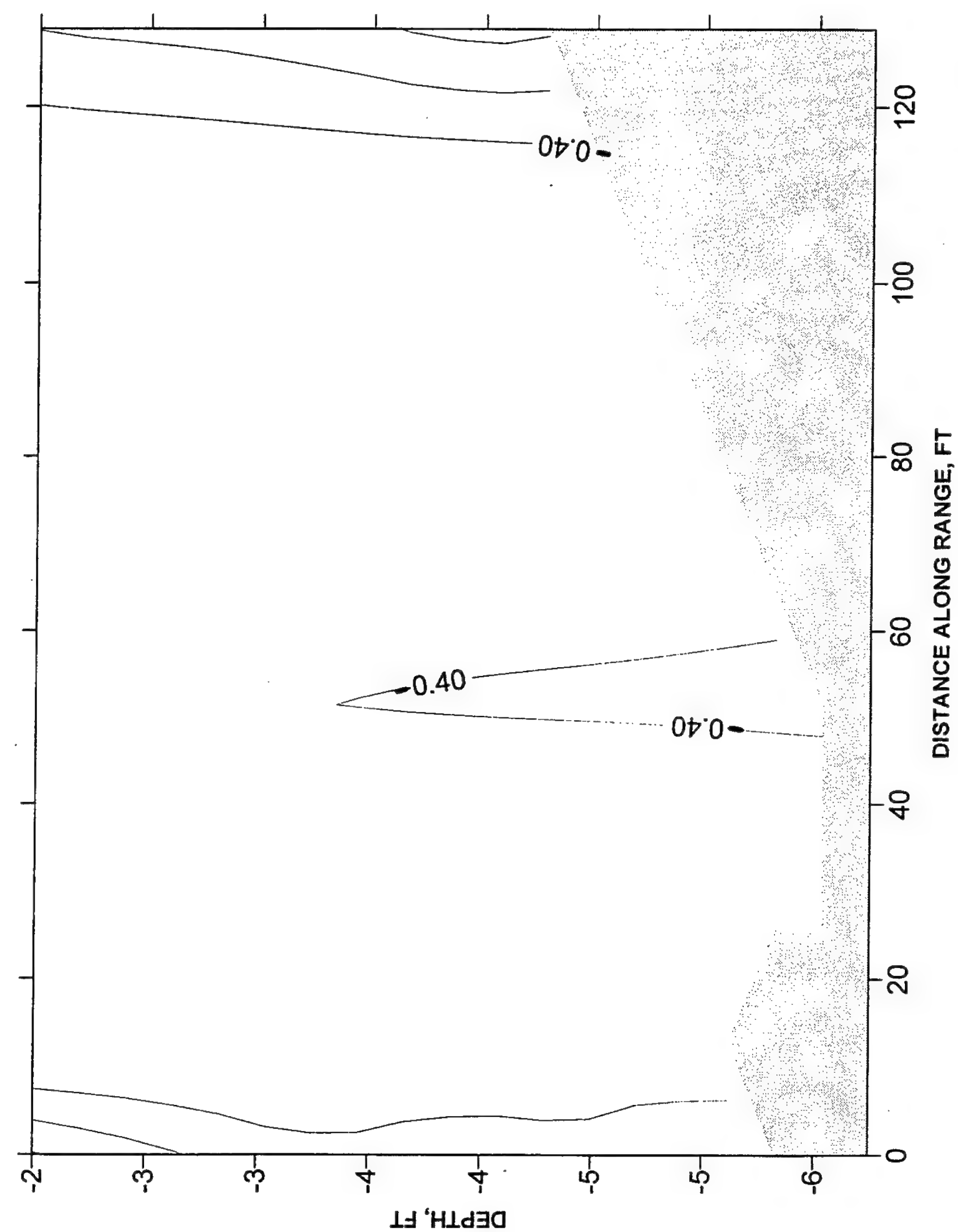
0.20



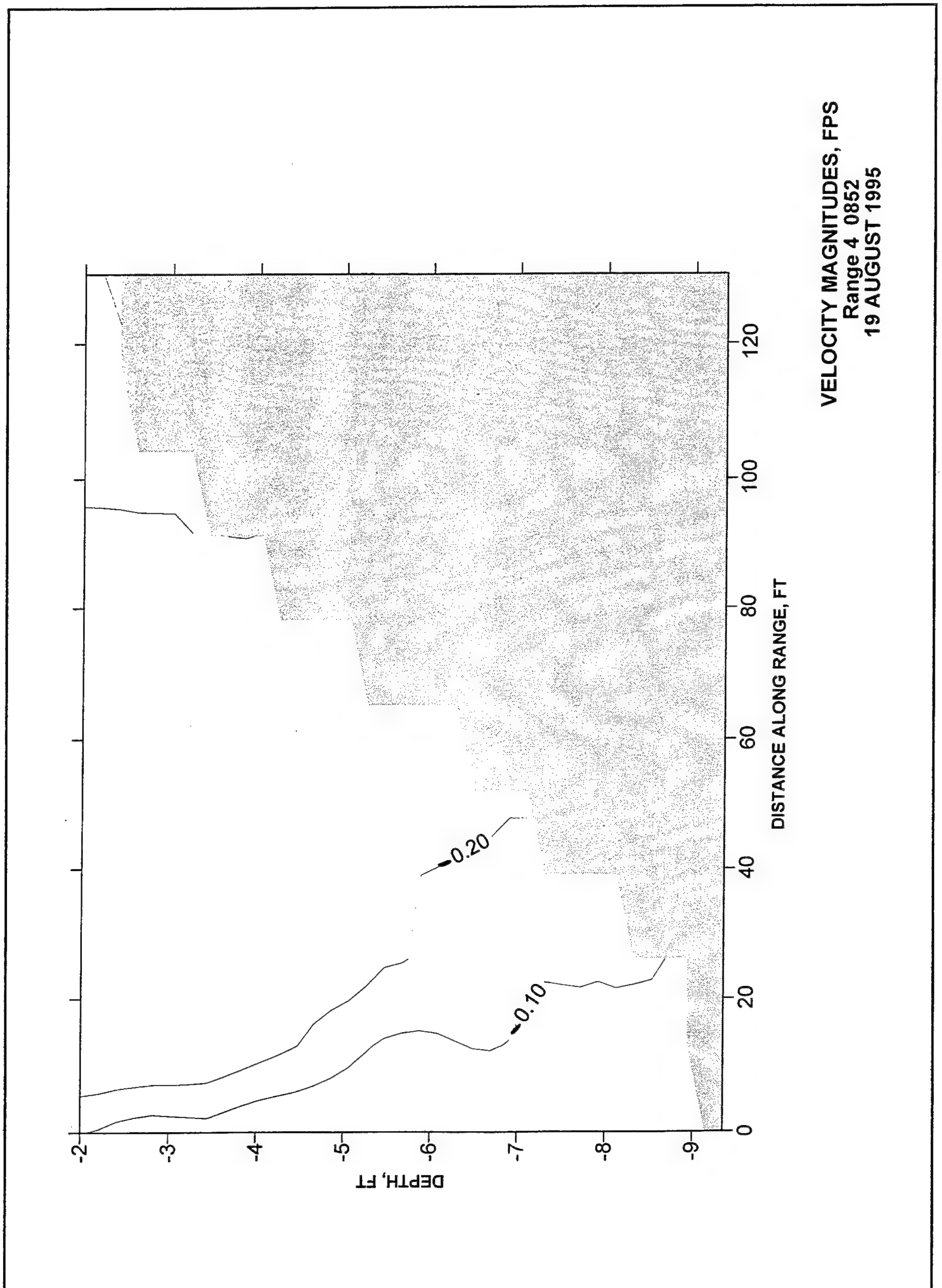
VELOCITY MAGNITUDES, FPS
Range 3 1635
19 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 4 0545
19 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 4 0740
19 AUGUST 1995


VELOCITY MAGNITUDES, FPS
Range 4 0852
19 AUGUST 1995
DISTANCE ALONG RANGE, FT
DEPTH, FT
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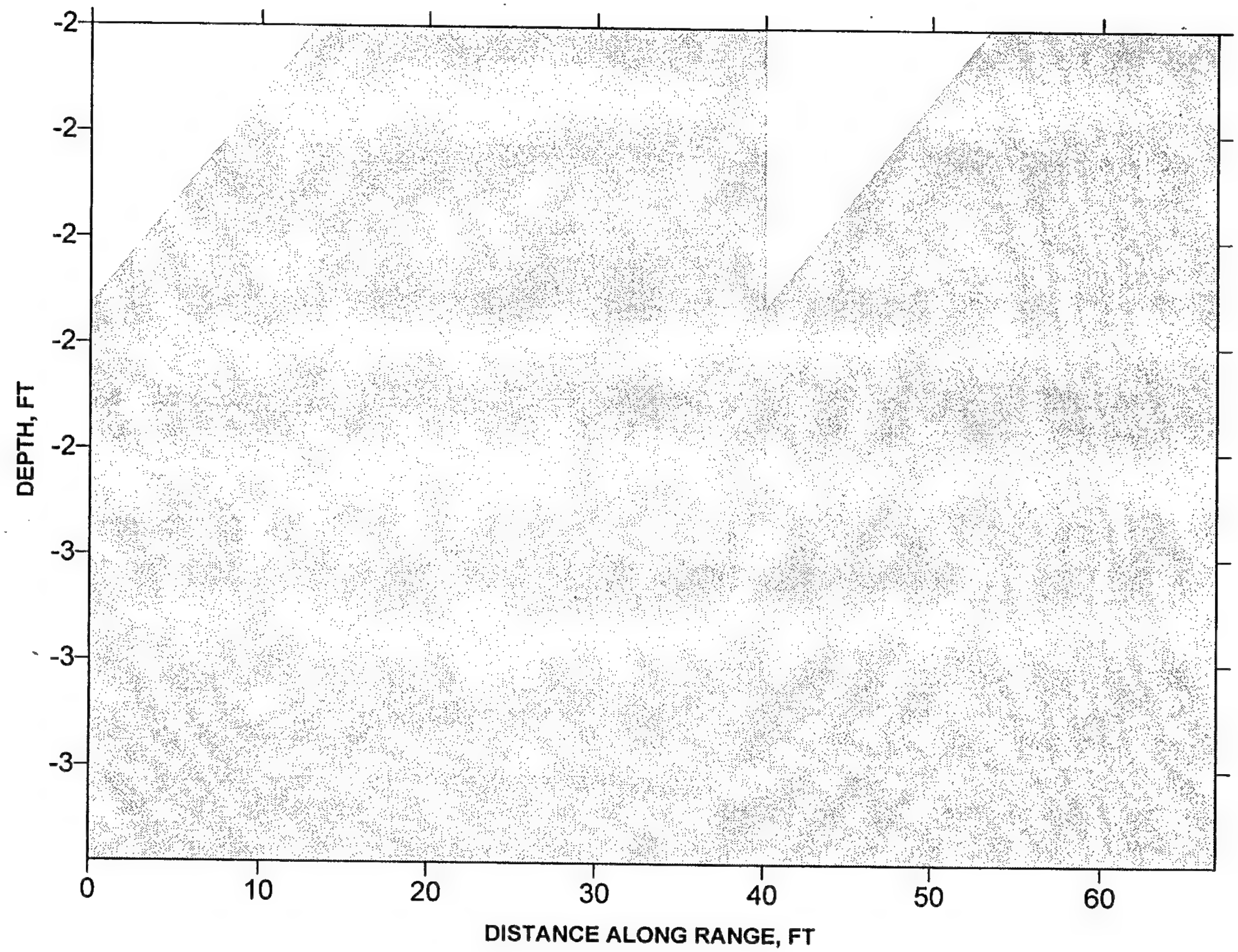
80
100
120
-2
-3
-4
-5
-6
-7
-8
-9
0.10
0.20



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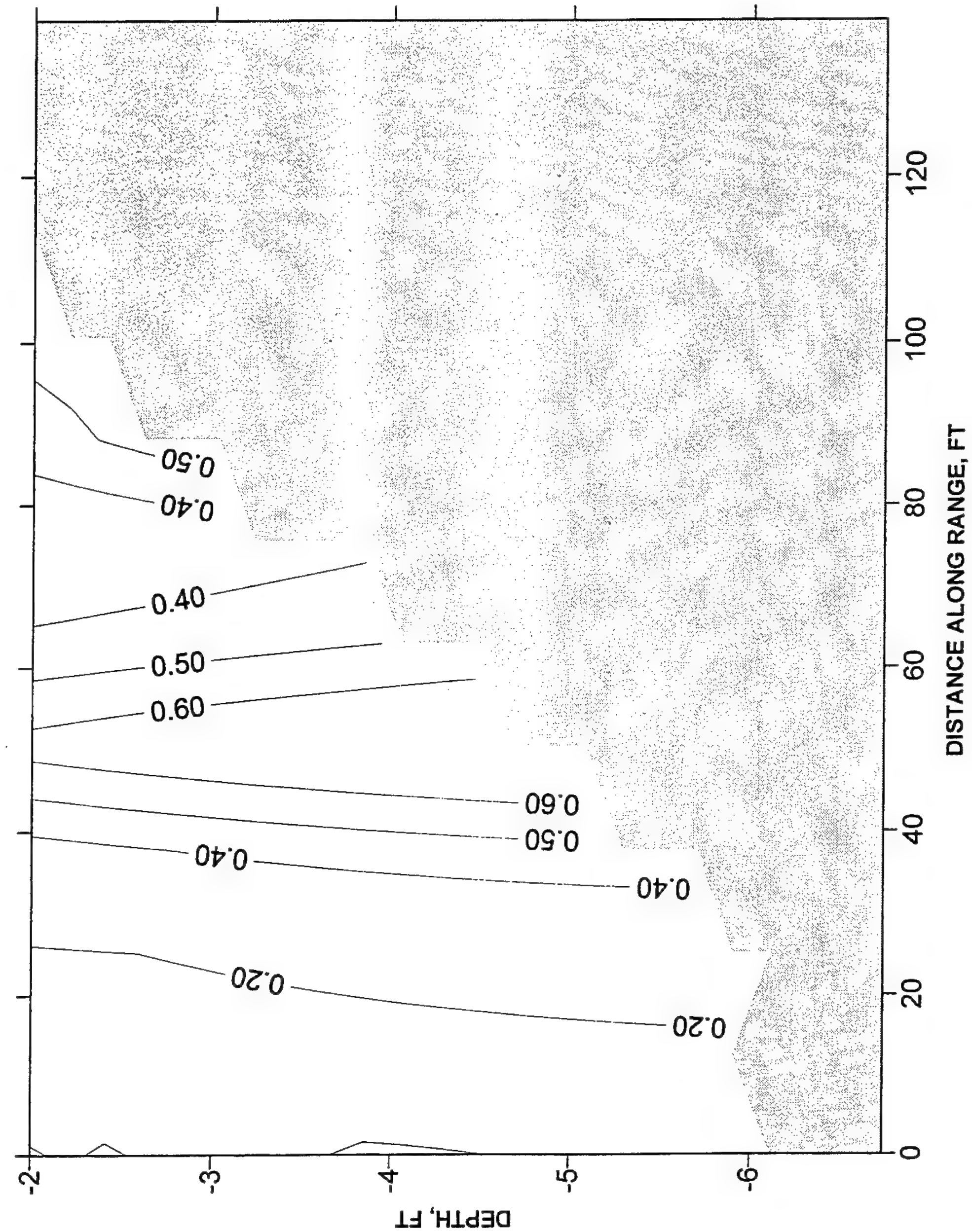
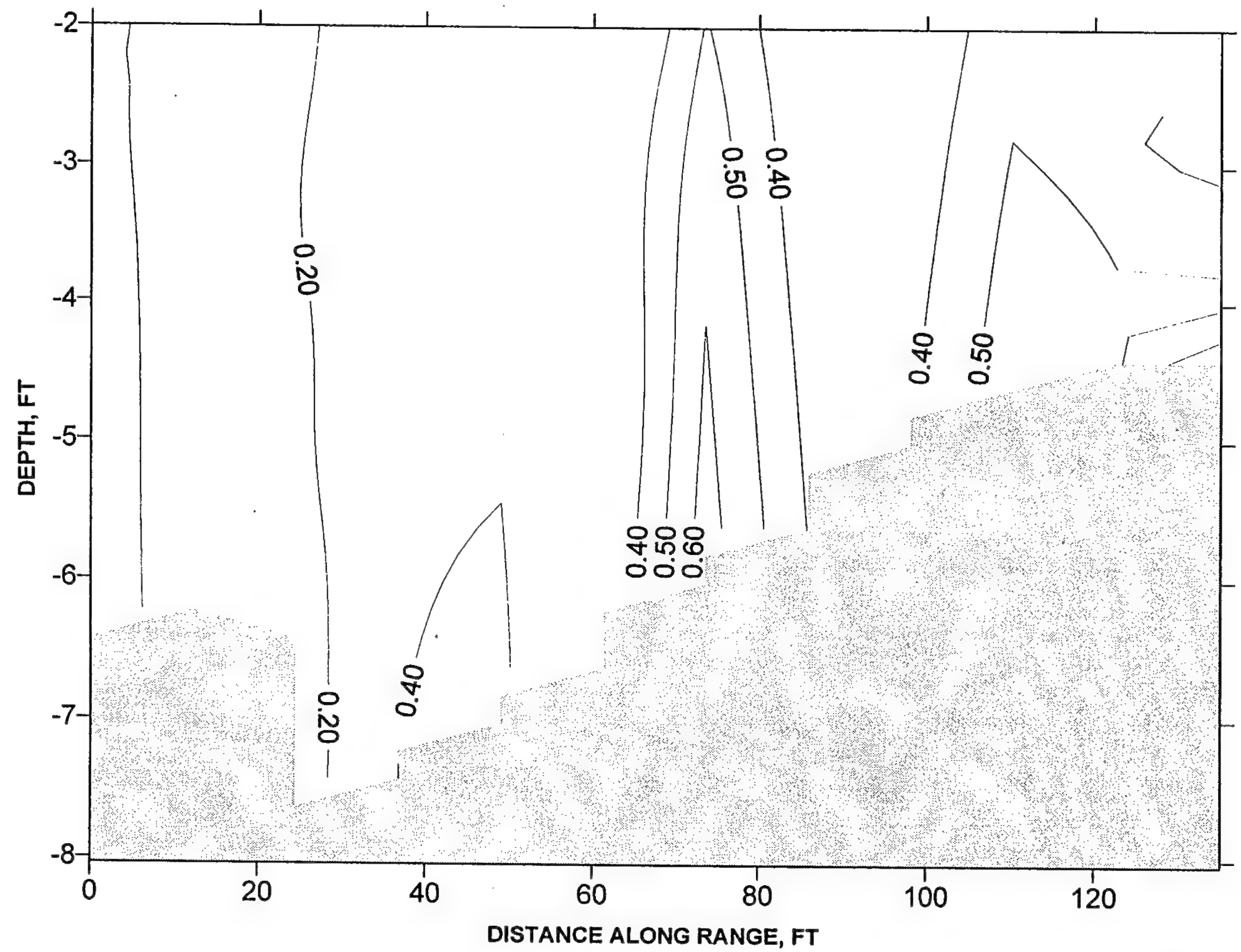
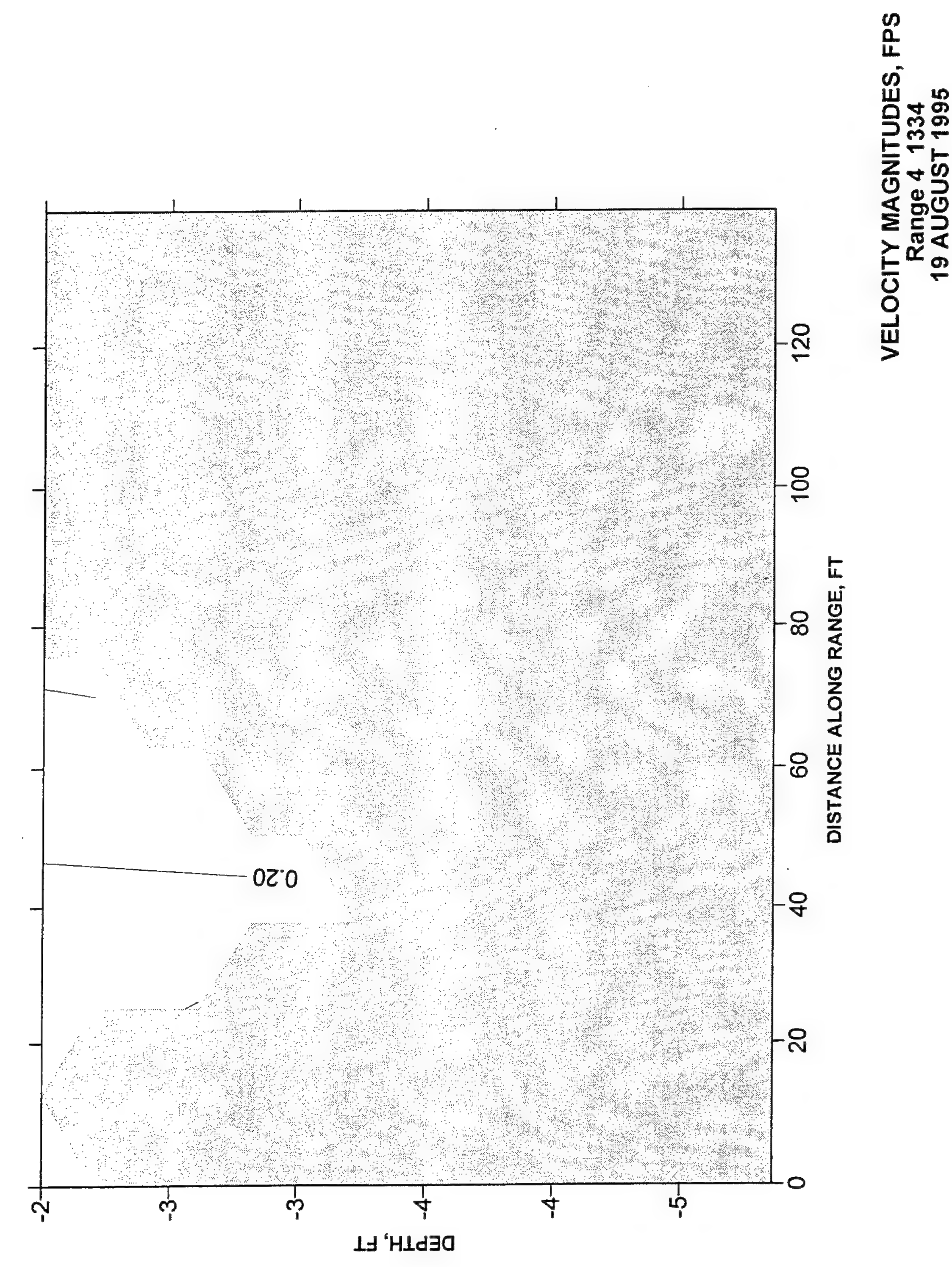


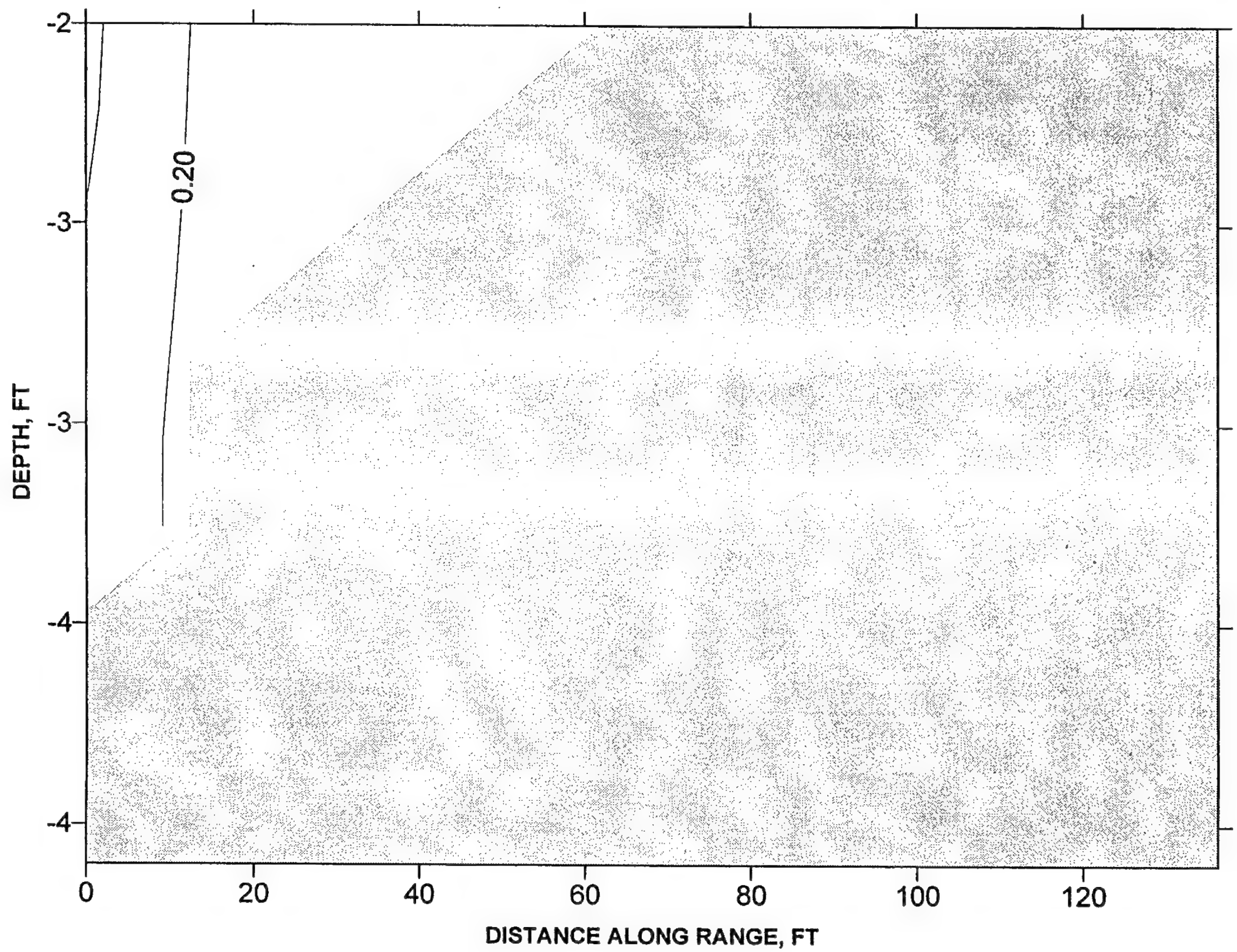
VELOCITY MAGNITUDES, FPS
Range 4 1121
19 AUGUST 1995

Plate 130

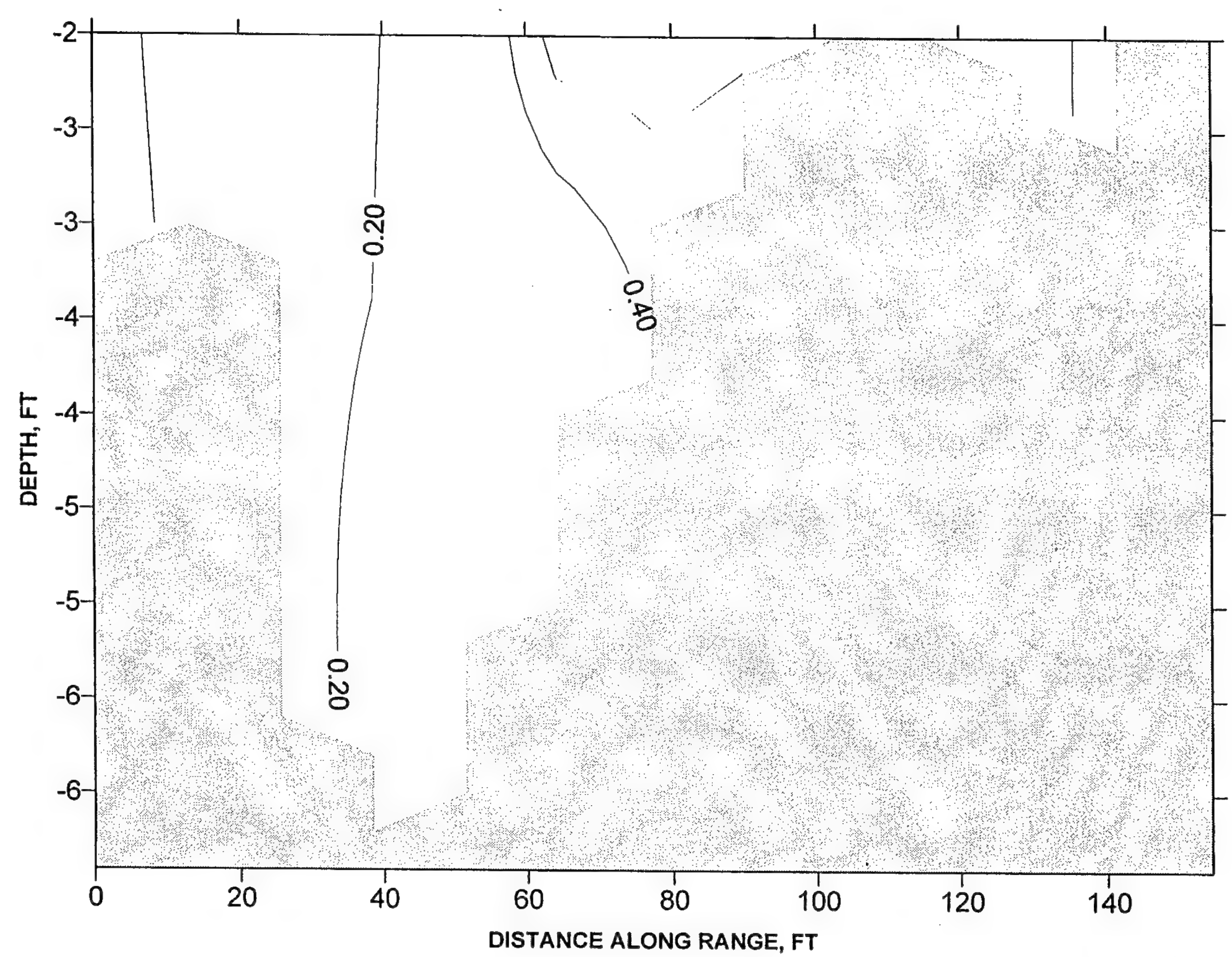


VELOCITY MAGNITUDES, FPS
Range 4 1235
19 AUGUST 1995

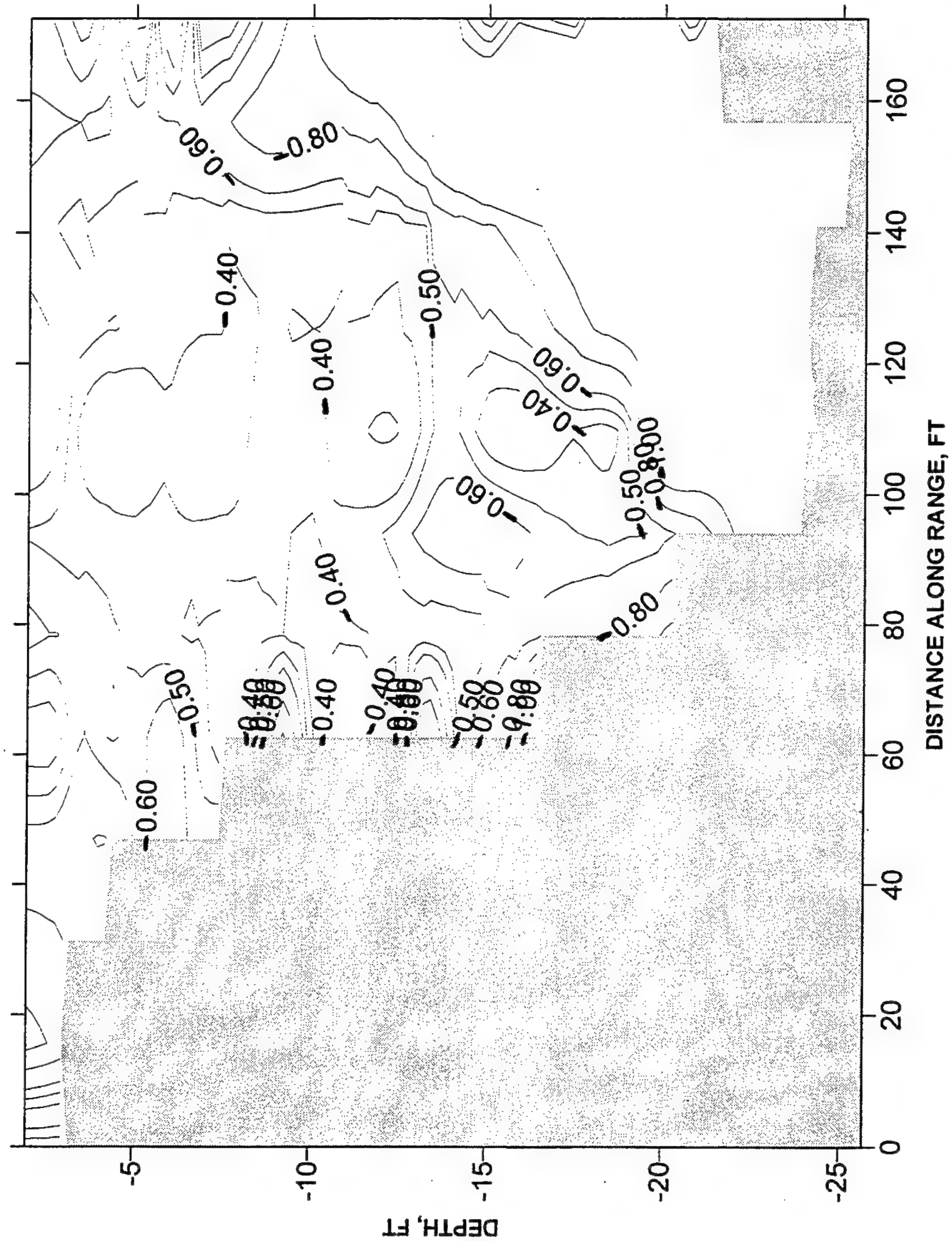

VELOCITY MAGNITUDES, FPS
Range 4 1334
19 AUGUST 1995
DISTANCE ALONG RANGE, FT
DEPTH, FT
0.20



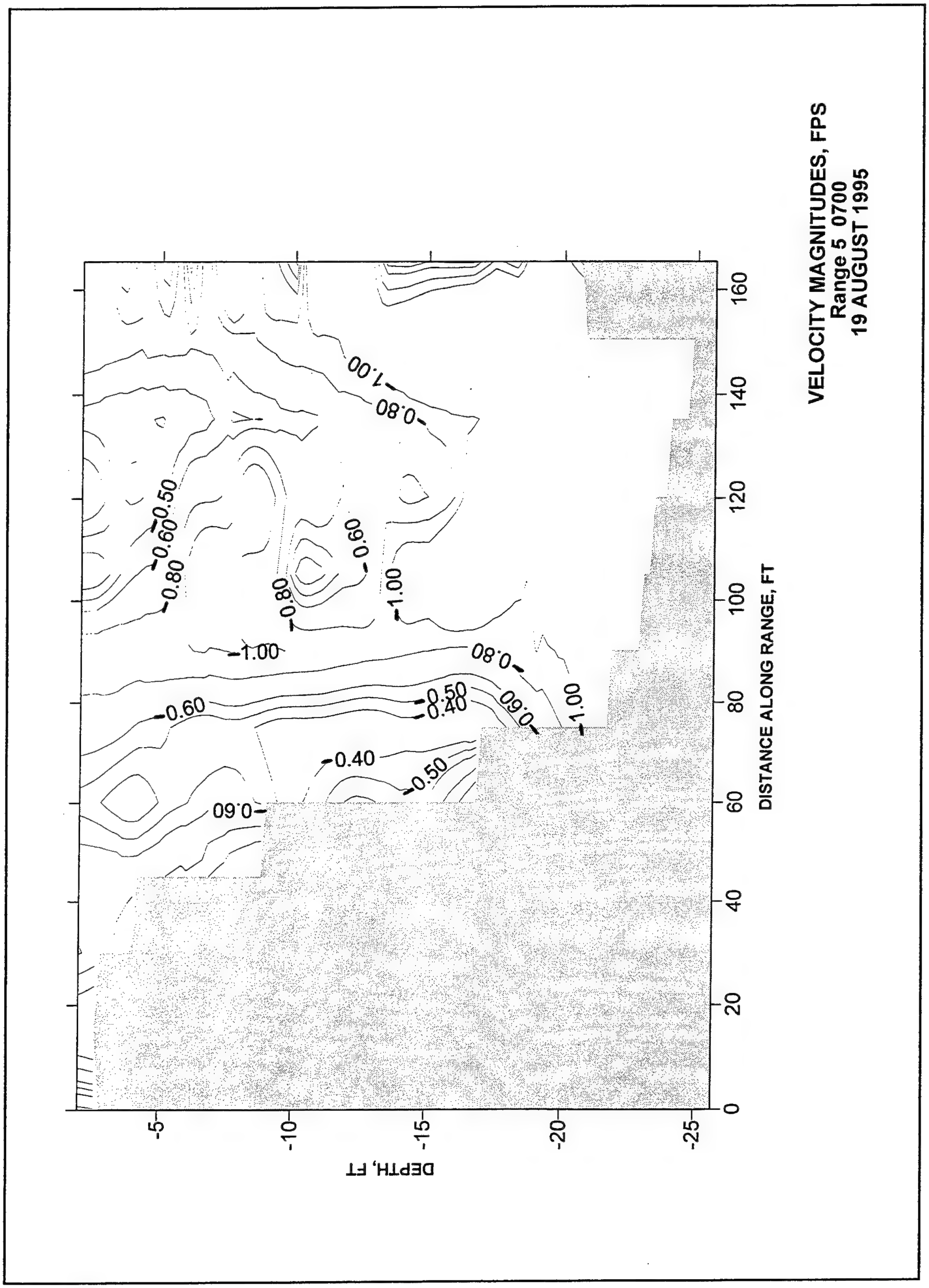
VELOCITY MAGNITUDES, FPS
Range 4 1500
19 AUGUST 1995



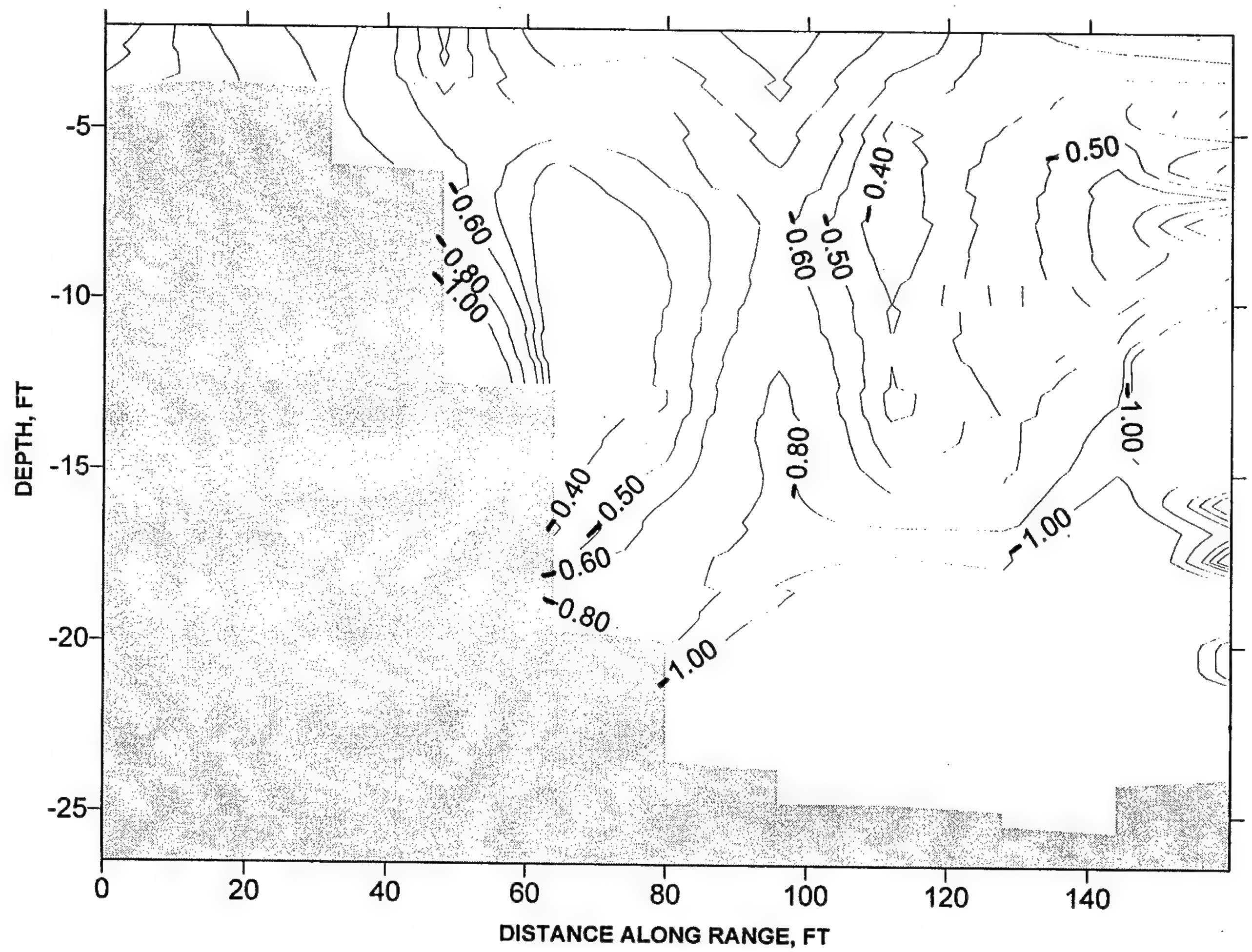
VELOCITY MAGNITUDES, FPS
Range 4 1603
19 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 5 0603
19 AUGUST 1995



VELOCITY MAGNITUDES, FPS
Range 5 0700
19 AUGUST 1995
DEPTH, FT
DISTANCE ALONG RANGE, FT
-5
-10
-15
-20
-25
0
20
40
60
80
100
120
140
160
0.40
0.50
0.60
0.80
1.00



VELOCITY MAGNITUDES, FPS
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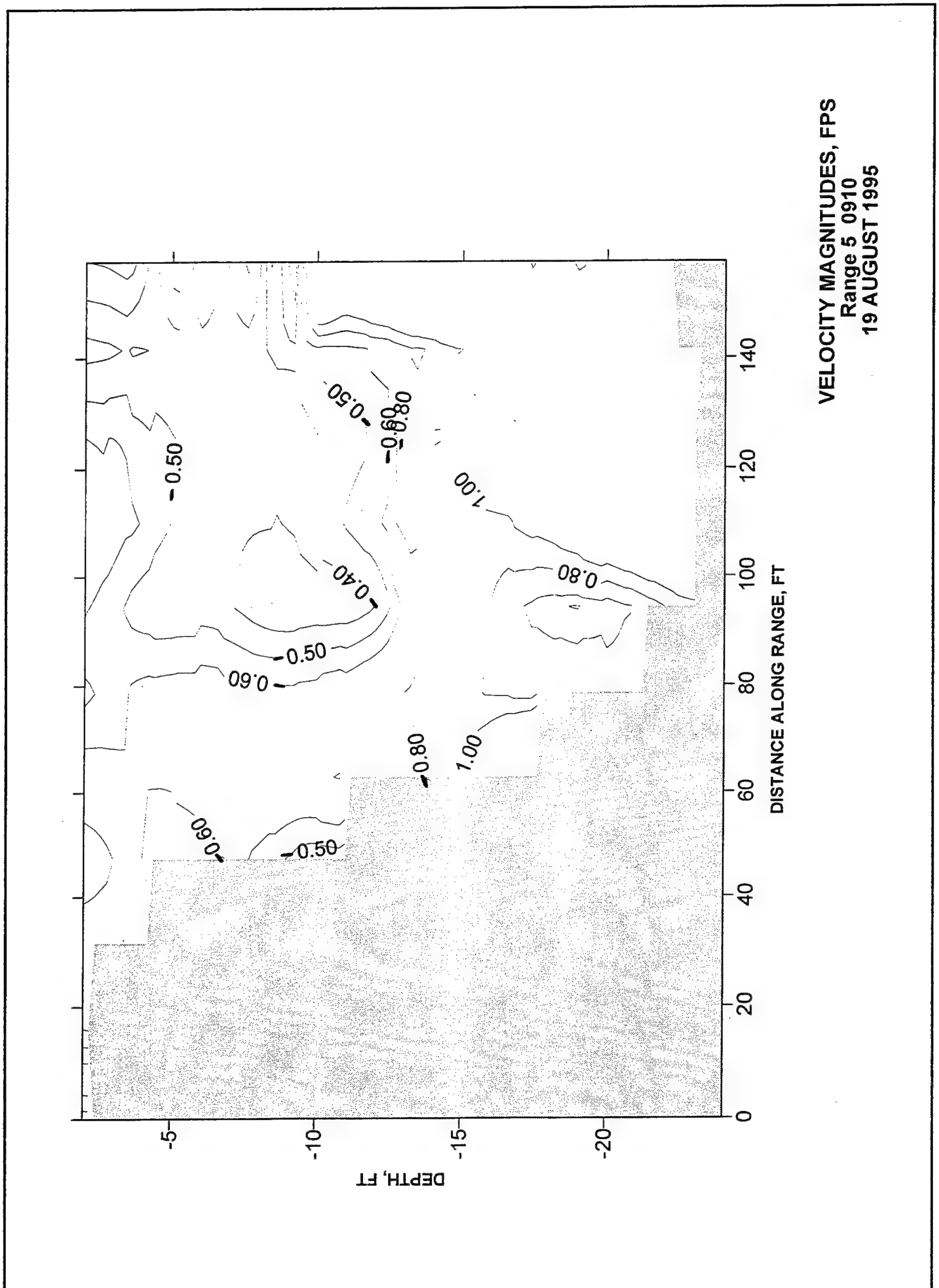
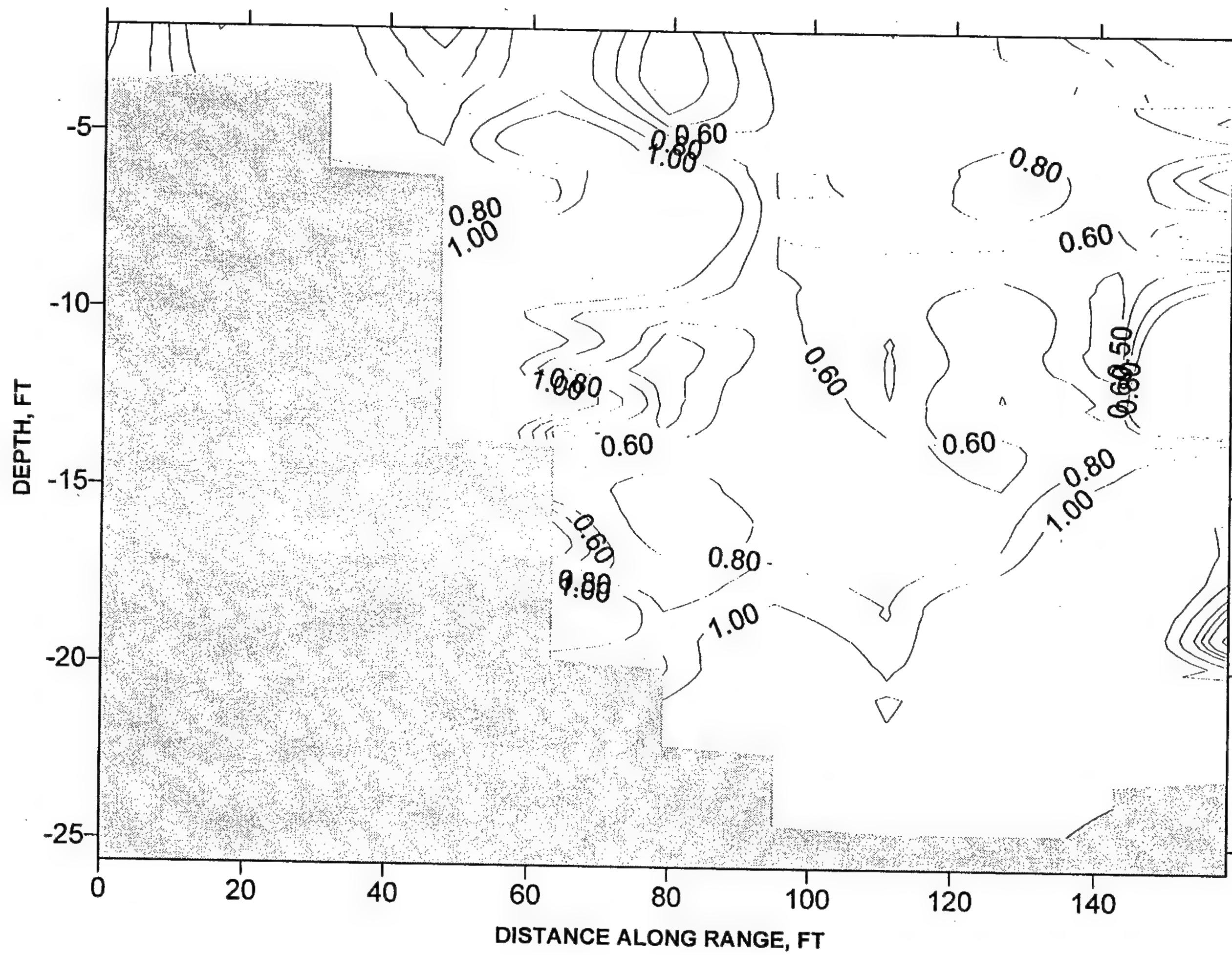
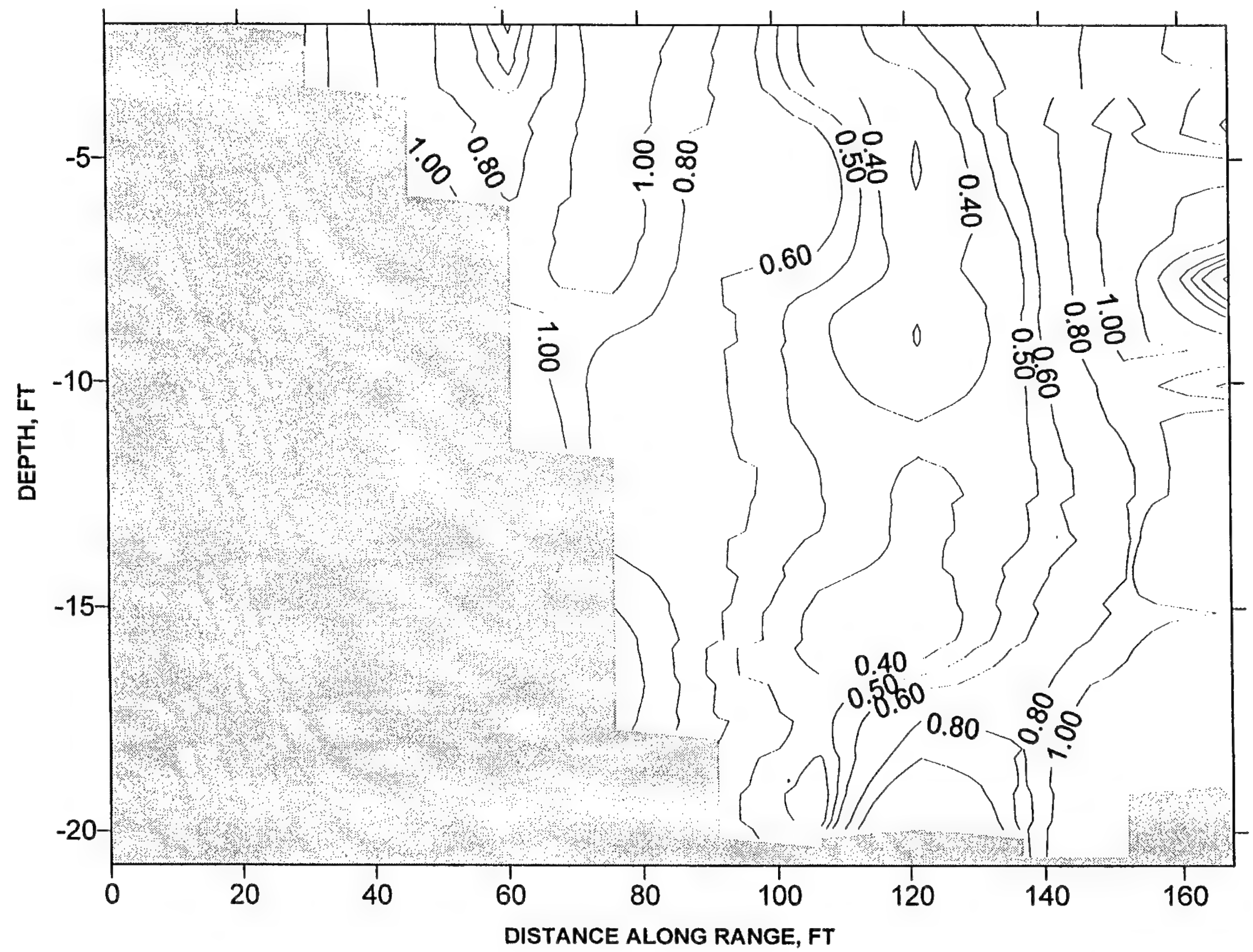
19 AUGUST 1995

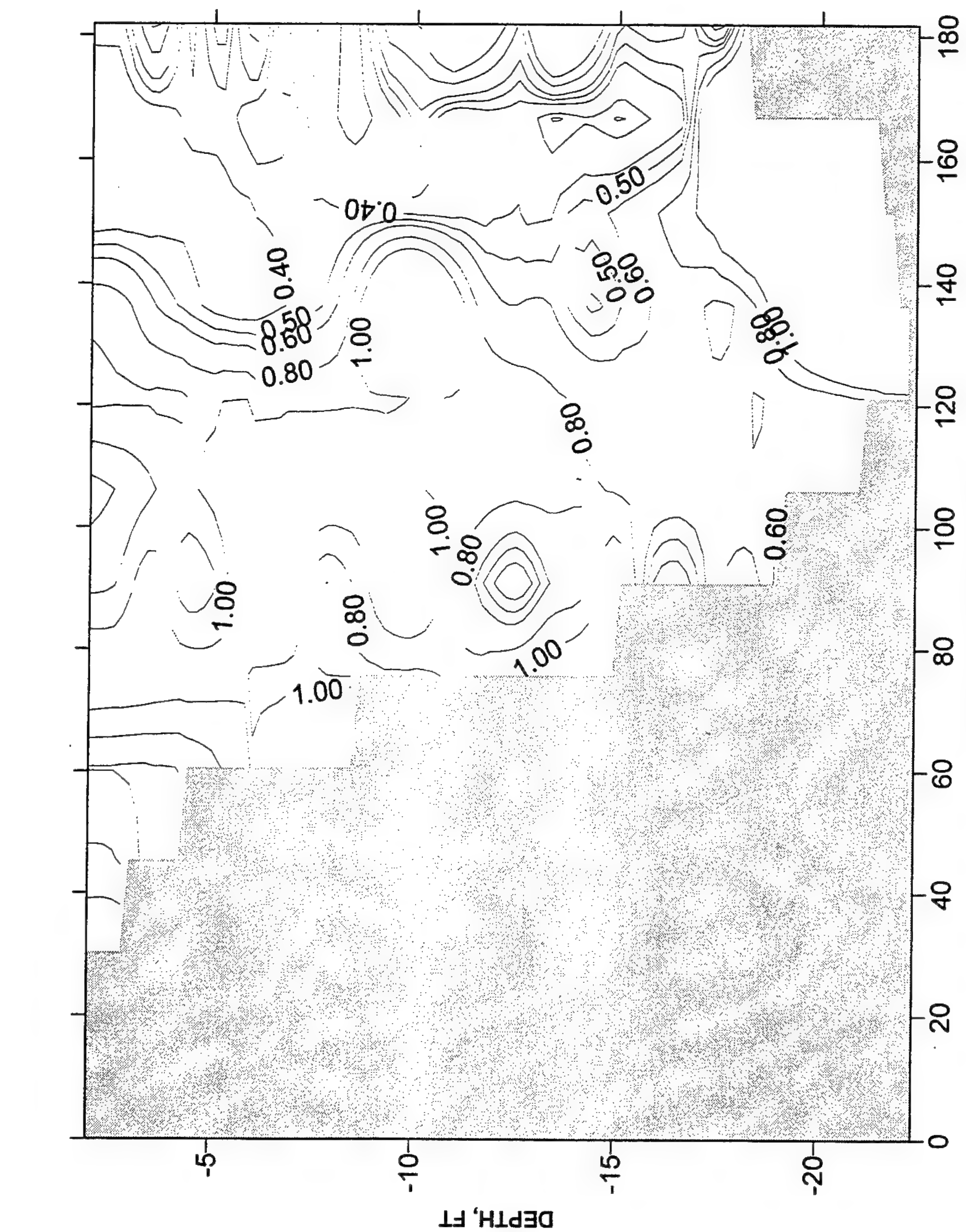

VELOCITY MAGNITUDES, FPS
Range 5 0910
19 AUGUST 1995
DISTANCE ALONG RANGE, FT
DEPTH, FT



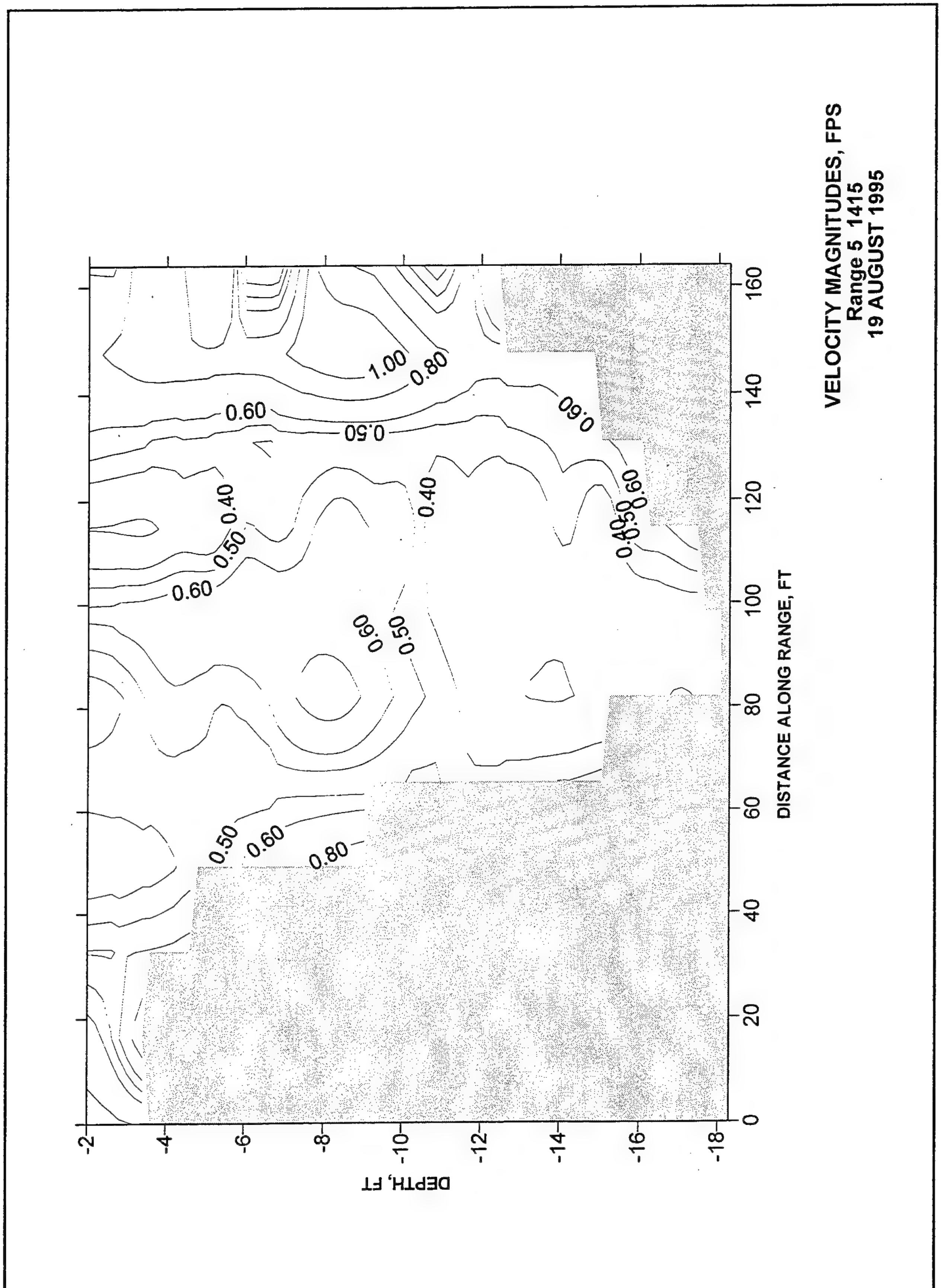
VELOCITY MAGNITUDES, FPS
Range 5 1008
19 AUGUST 1995

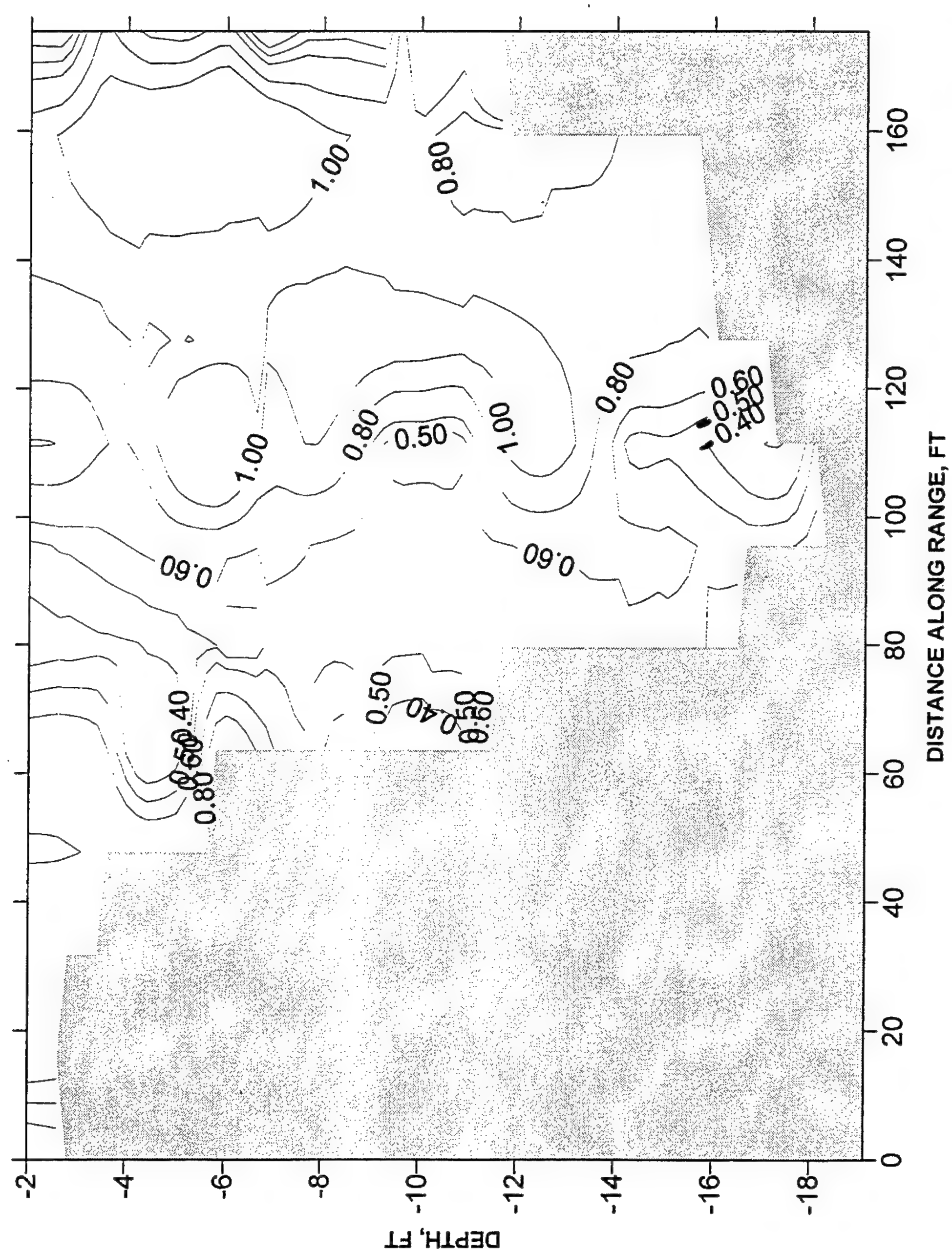


VELOCITY MAGNITUDES, FPS
Range 5 1140
19 AUGUST 1995

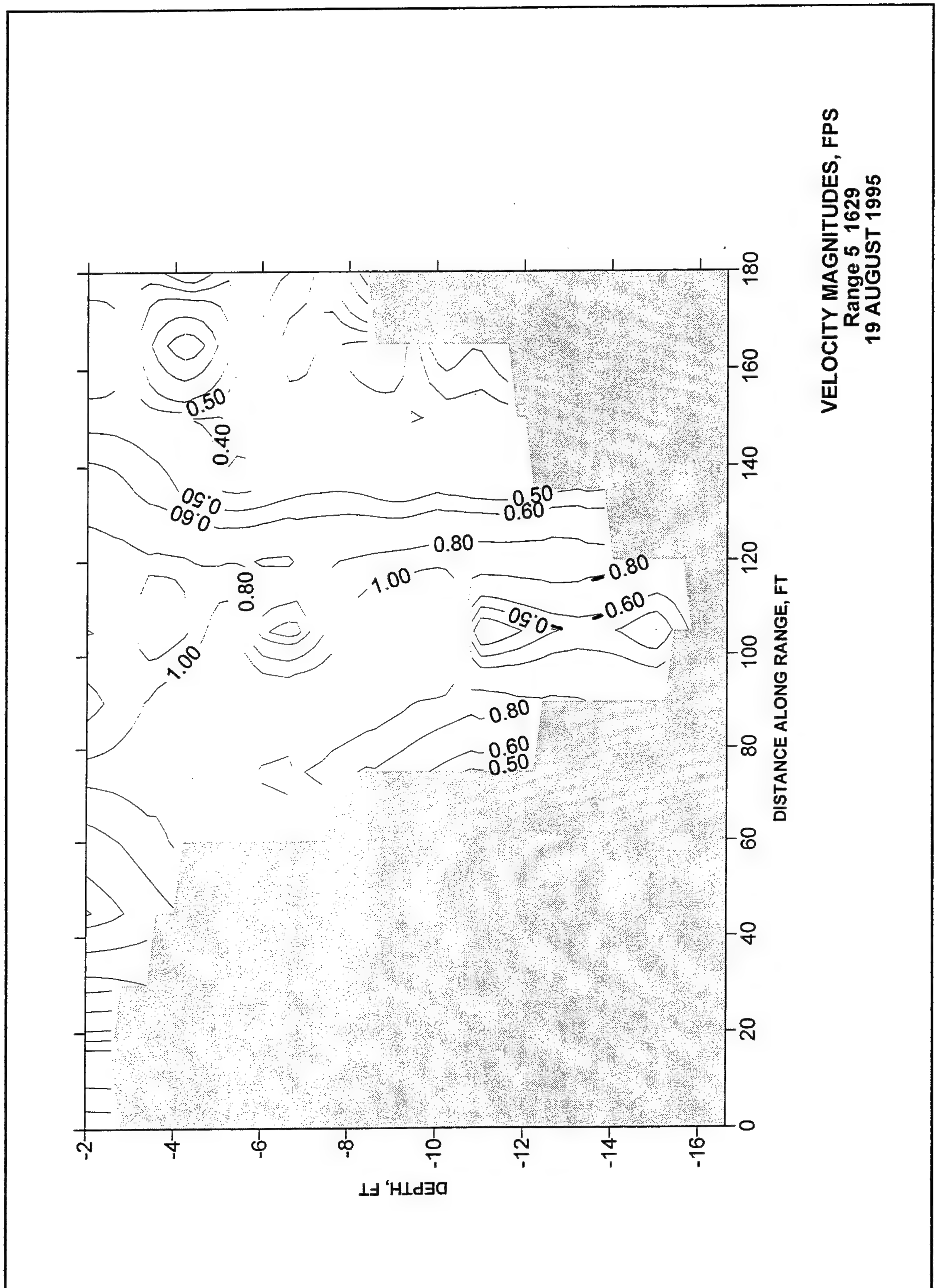


VELOCITY MAGNITUDES, FPS
Range 5 1254
19 AUGUST 1995


VELOCITY MAGNITUDES, FPS
Range 5 1415
19 AUGUST 1995
DISTANCE ALONG RANGE, FT
DEPTH, FT
0
20
40
60
80
100
120
140
160
-2
-4
-6
-8
-10
-12
-14
-16
-18
1.00
0.80
0.60
0.50
0.40



VELOCITY MAGNITUDES, FPS
Range 5 1518
19 AUGUST 1995


VELOCITY MAGNITUDES, FPS
Range 5 1629
19 AUGUST 1995
DISTANCE ALONG RANGE, FT
DEPTH, FT
0
20
40
60
80
100
120
140
160
180
-2
-4
-6
-8
-10
-12
-14
-16
0.50
0.40
0.50
0.60
0.50
0.60
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0.80
1.00
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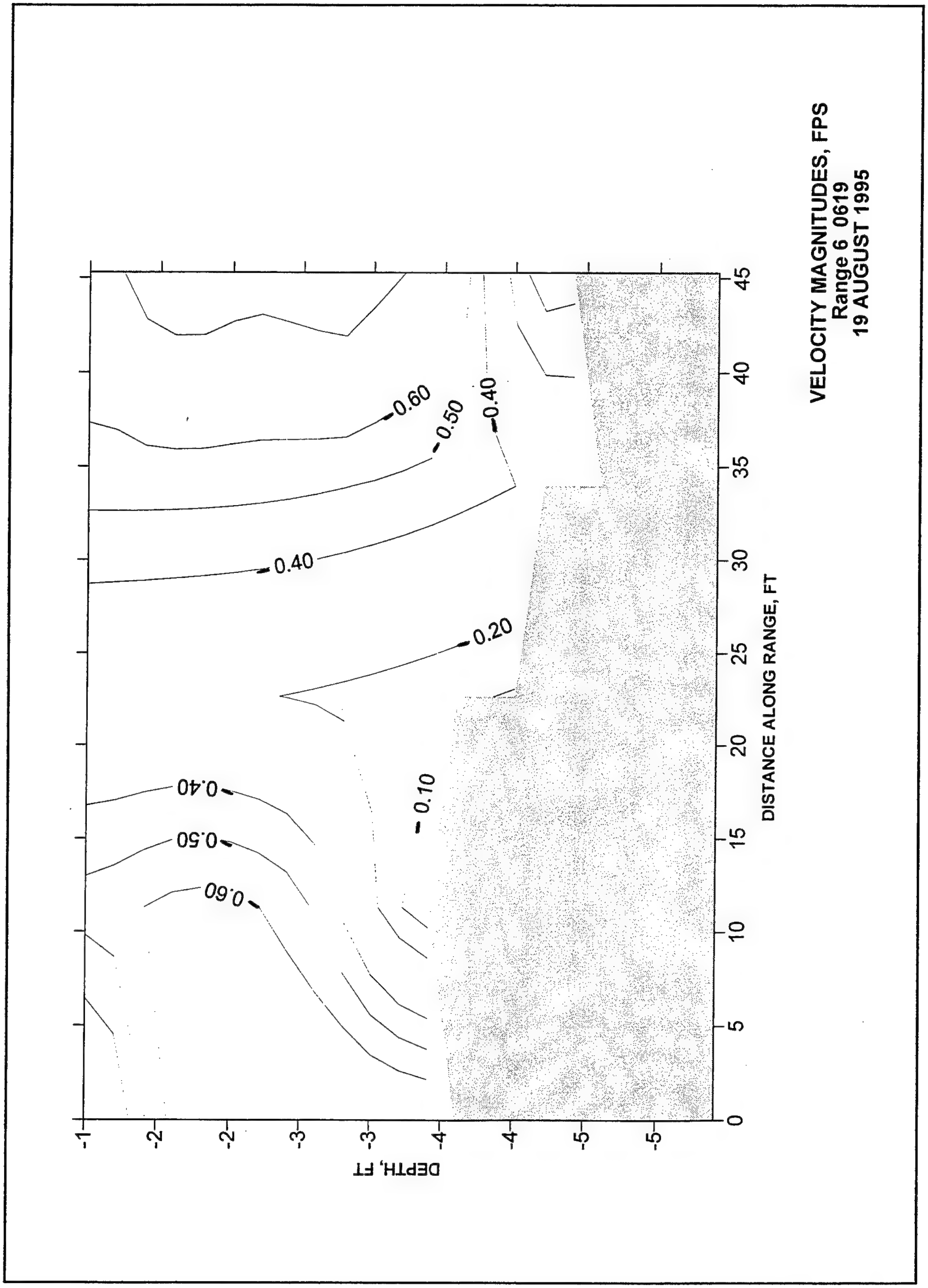
0.50
1.00
0.80
0.60
0.50


VELOCITY MAGNITUDES, FPS
Range 6 0619
19 AUGUST 1995
DEPTH, FT
DISTANCE ALONG RANGE, FT
0.60
0.50
0.40
0.20
0.10
0
5
10
15
20
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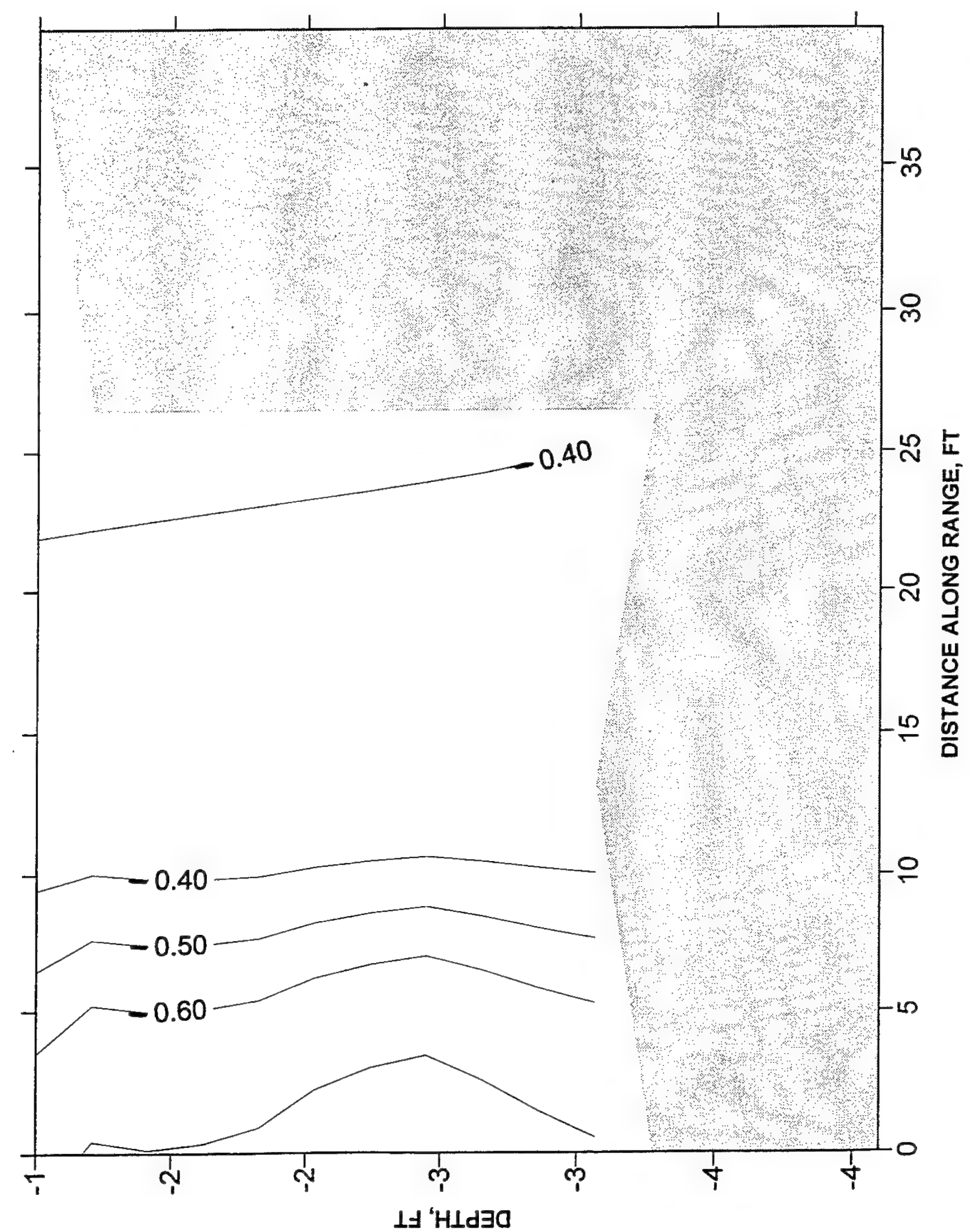
30
35
40
45
-1
-2
-2
-3
-3
-4
-4
-5
-5



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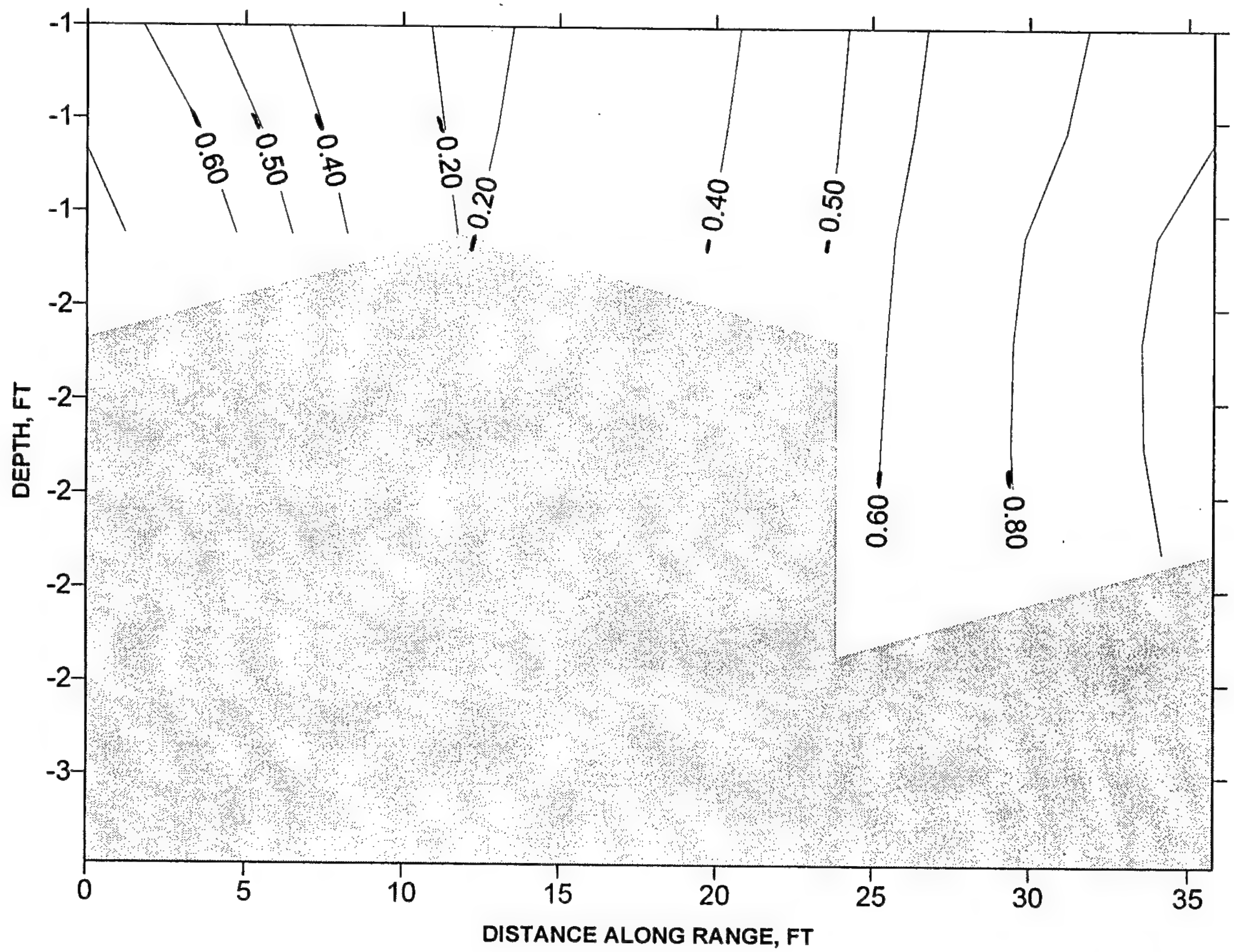
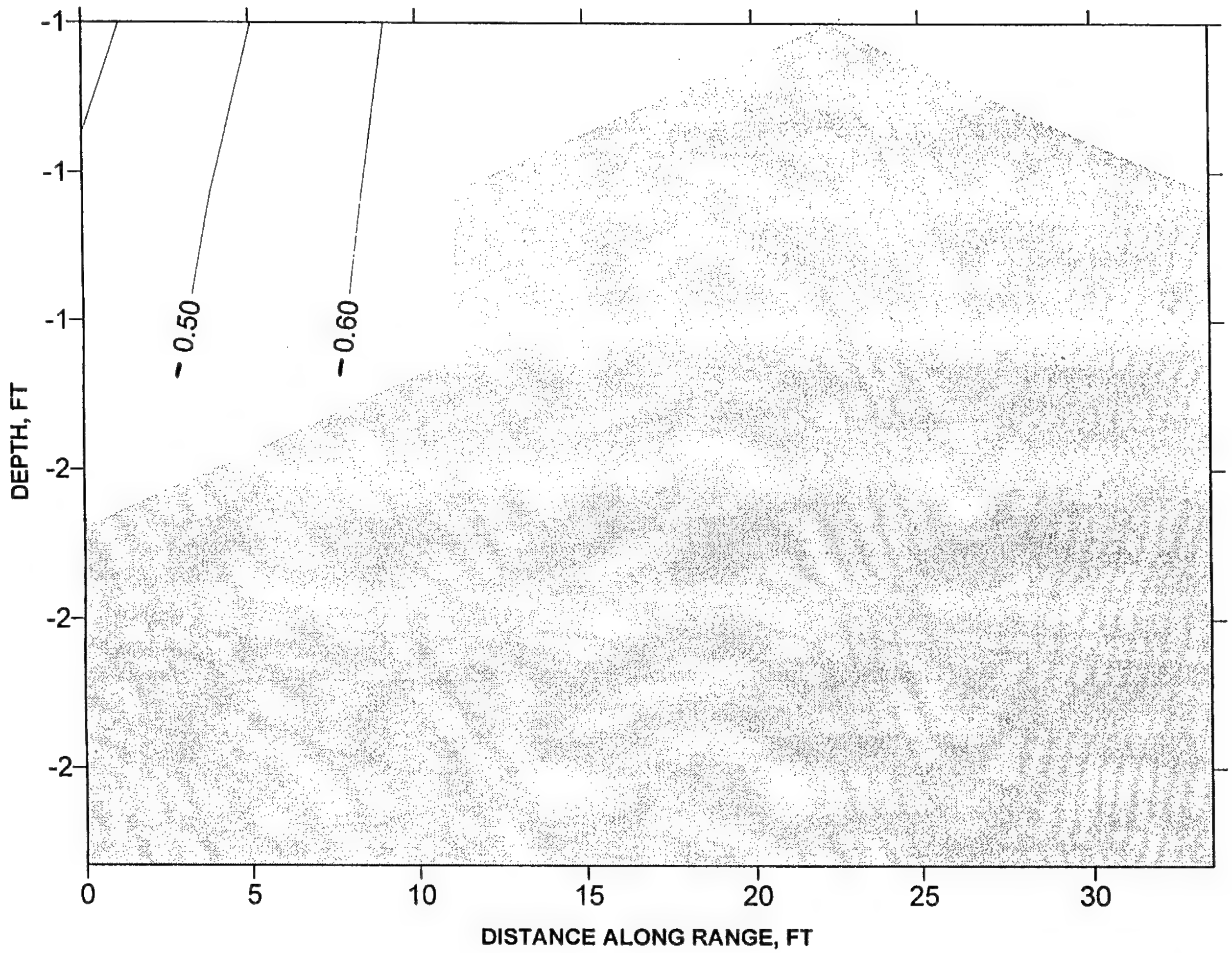


VELOCITY MAGNITUDES, FPS
Range 6 0822
19 AUGUST 1995



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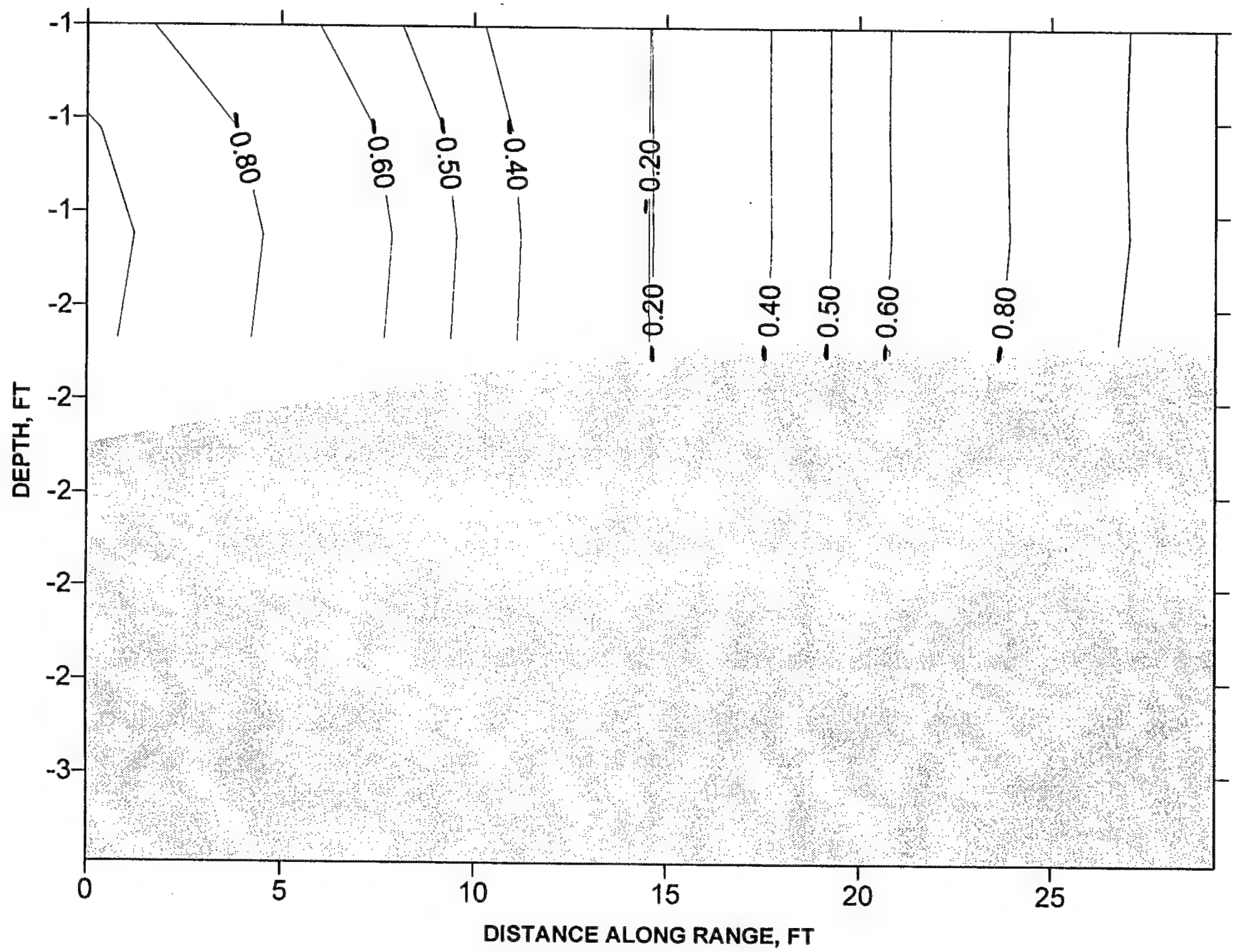
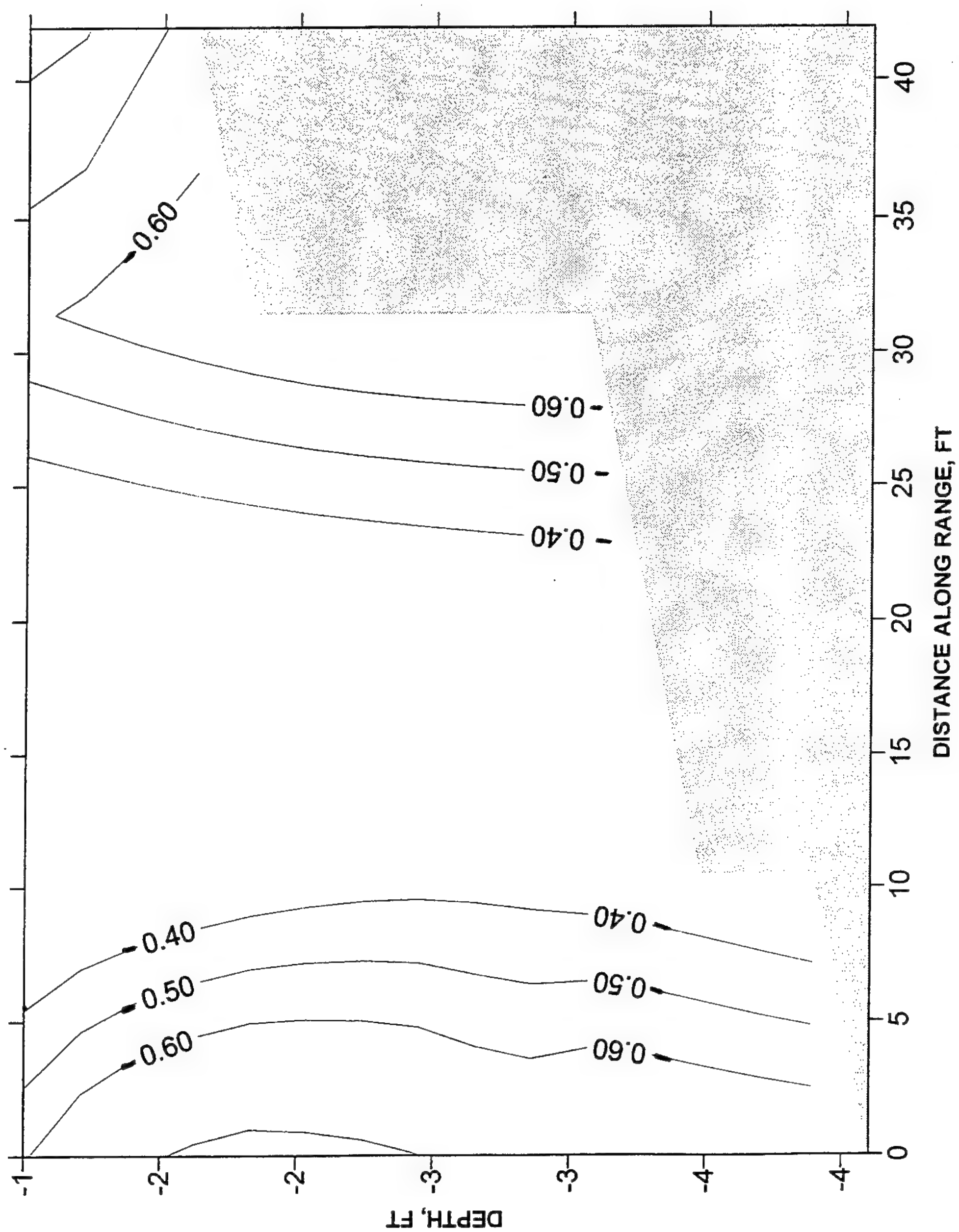
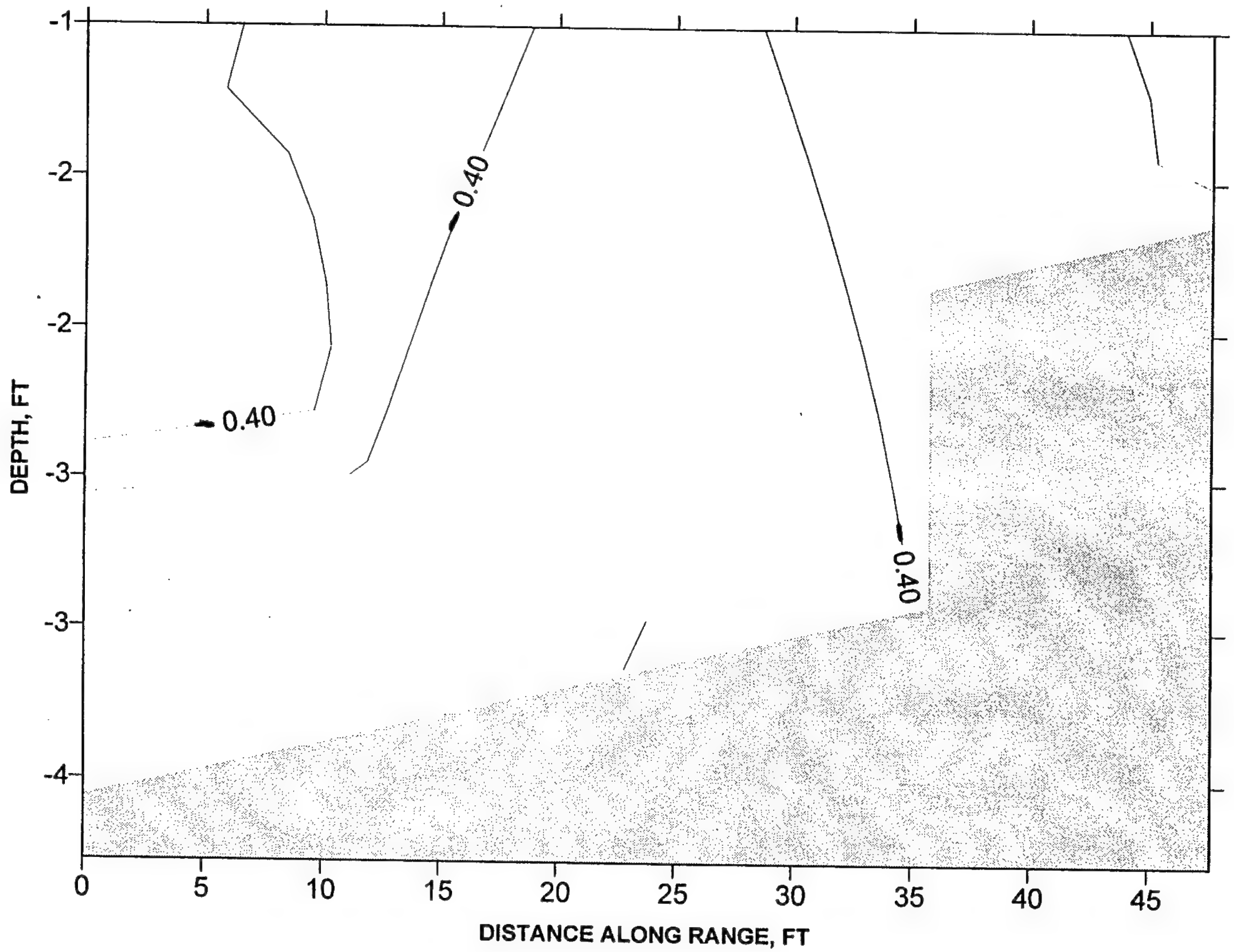
19 AUGUST 1995



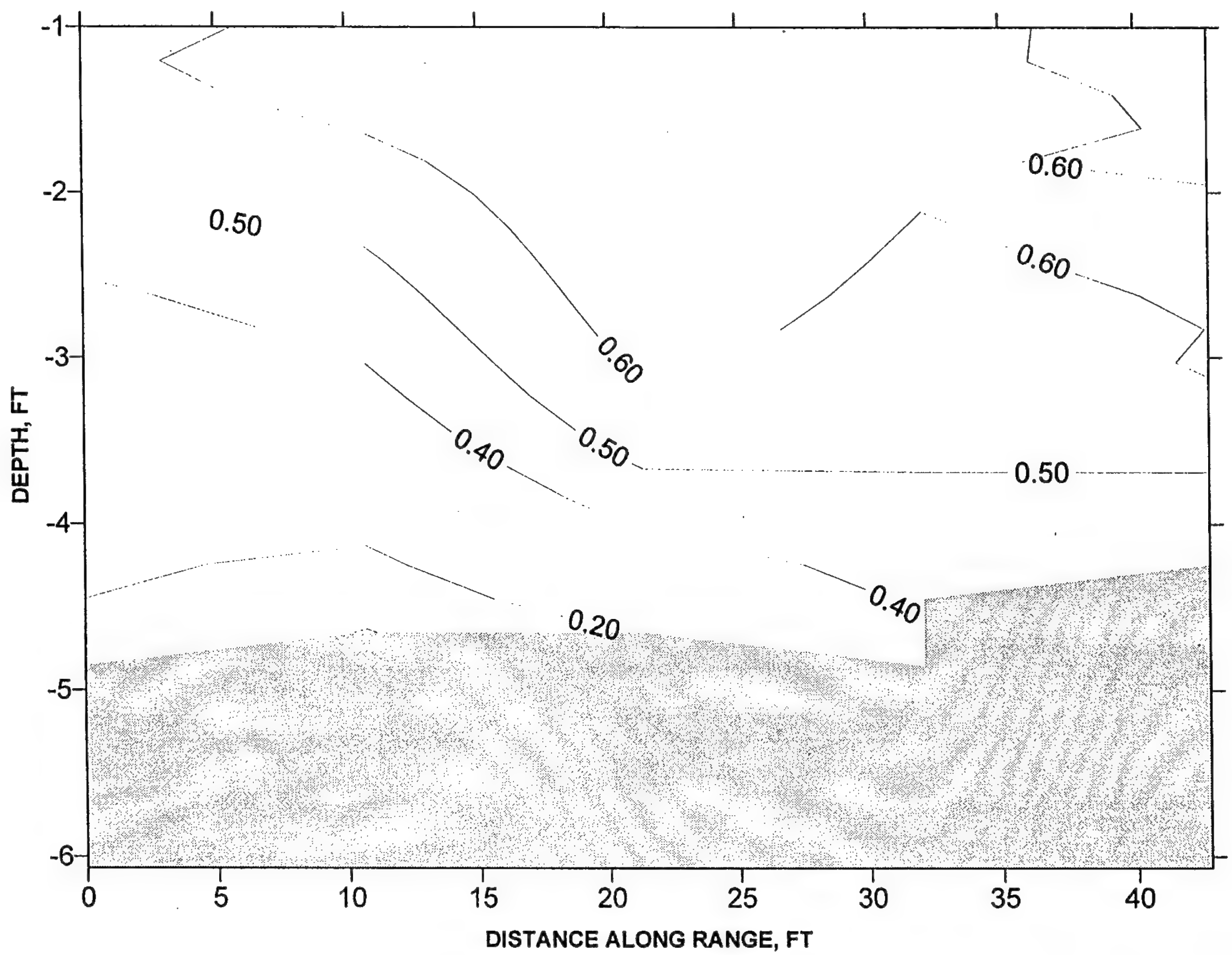
VELOCITY MAGNITUDES, FPS
Range 6 1025
19 AUGUST 1995



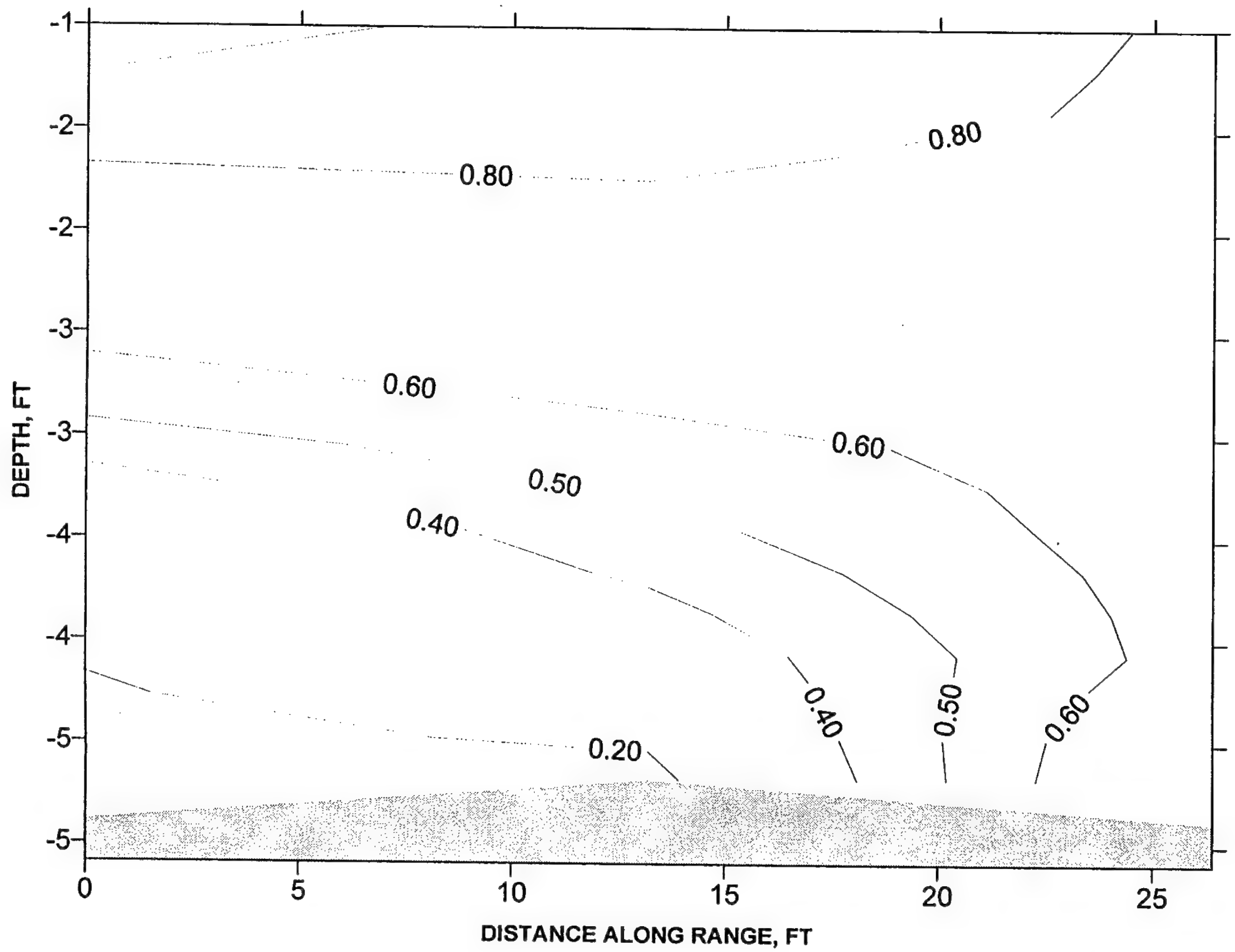
VELOCITY MAGNITUDES, FPS
Range 6 1155
19 AUGUST 1995



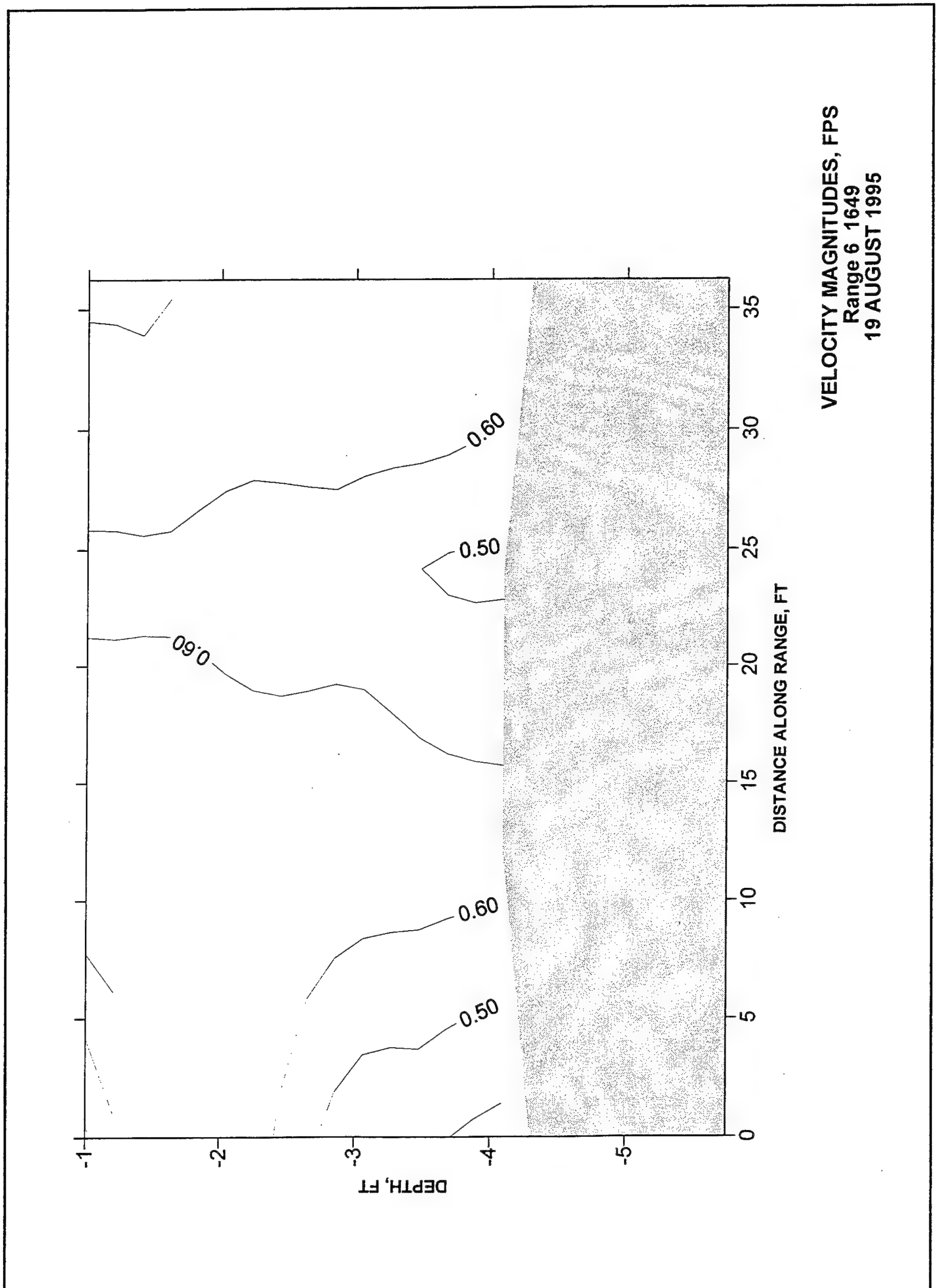
VELOCITY MAGNITUDES, FPS
Range 6 1308
19 AUGUST 1995

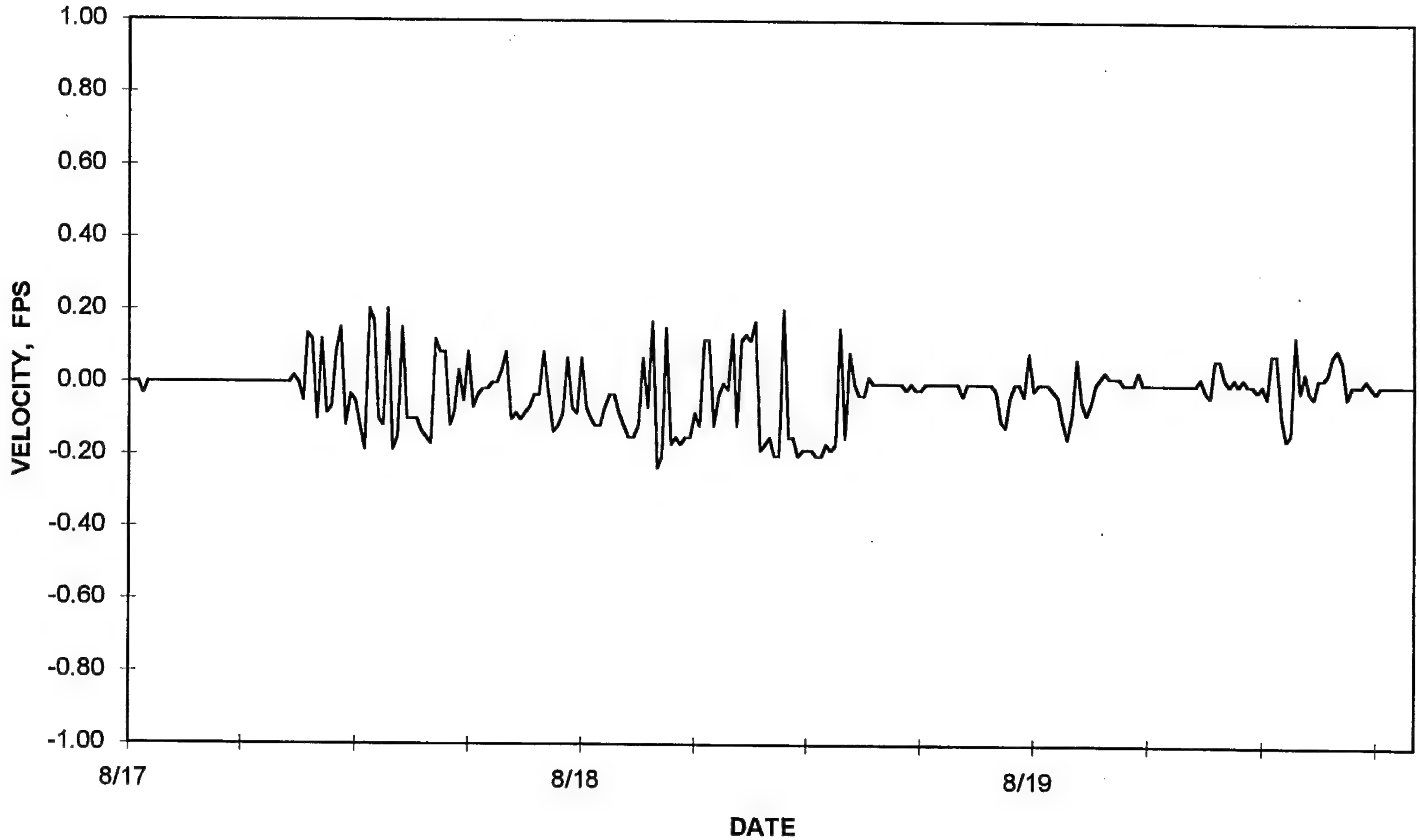


VELOCITY MAGNITUDES, FPS
Range 6 1435
19 AUGUST 1995

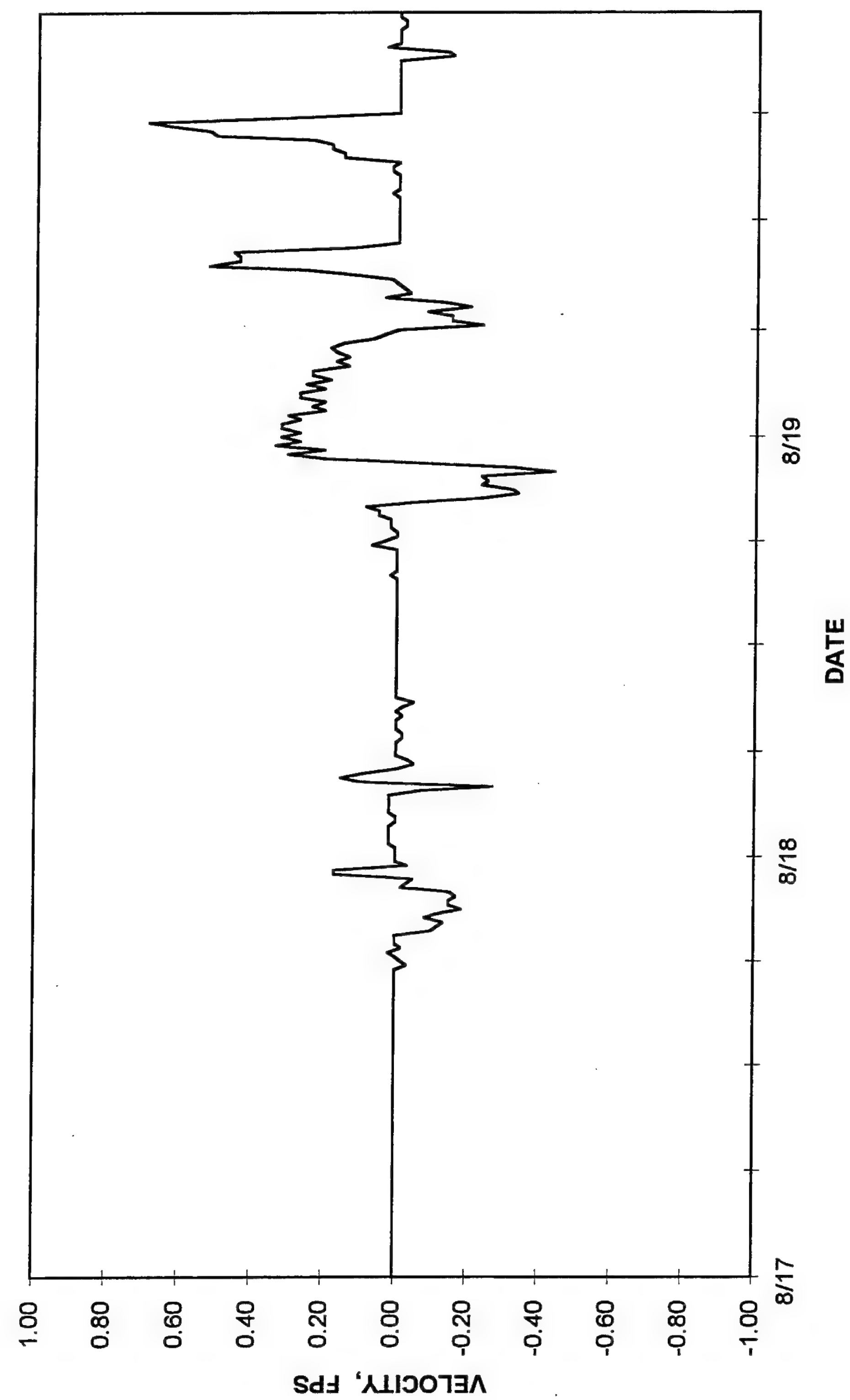


VELOCITY MAGNITUDES, FPS
Range 6 1535
19 AUGUST 1995

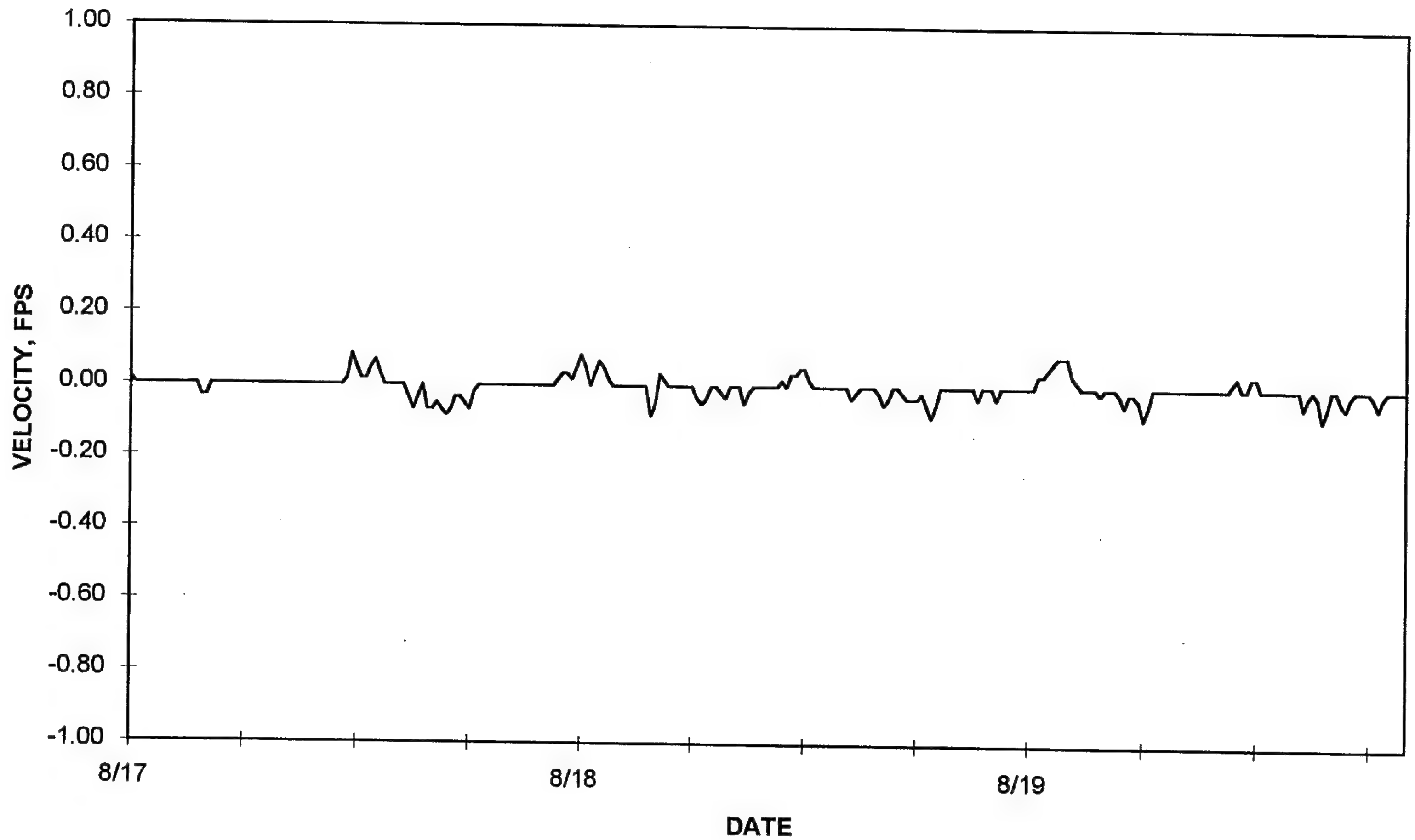

VELOCITY MAGNITUDES, FPS
Range 6 1649
19 AUGUST 1995
DEPTH, FT
DISTANCE ALONG RANGE, FT
0.60
0.50
0.60
0.60
0.50
-1
-2
-3
-4
-5
0
5
10
15
20
25
30
35



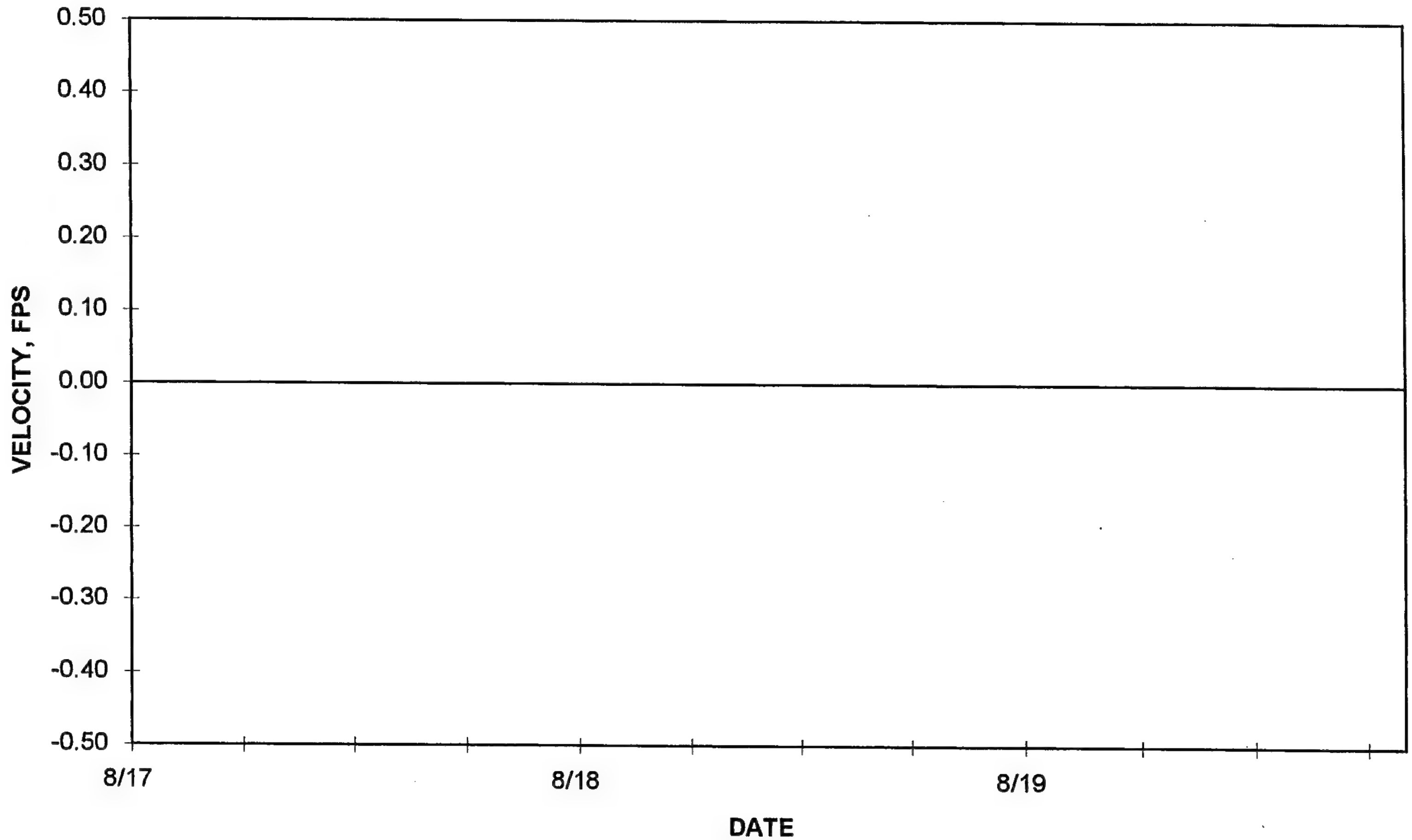
FIXED-DEPTH CURRENT METER
VELOCITIES
STATION S1.0
8/17 - 19/95



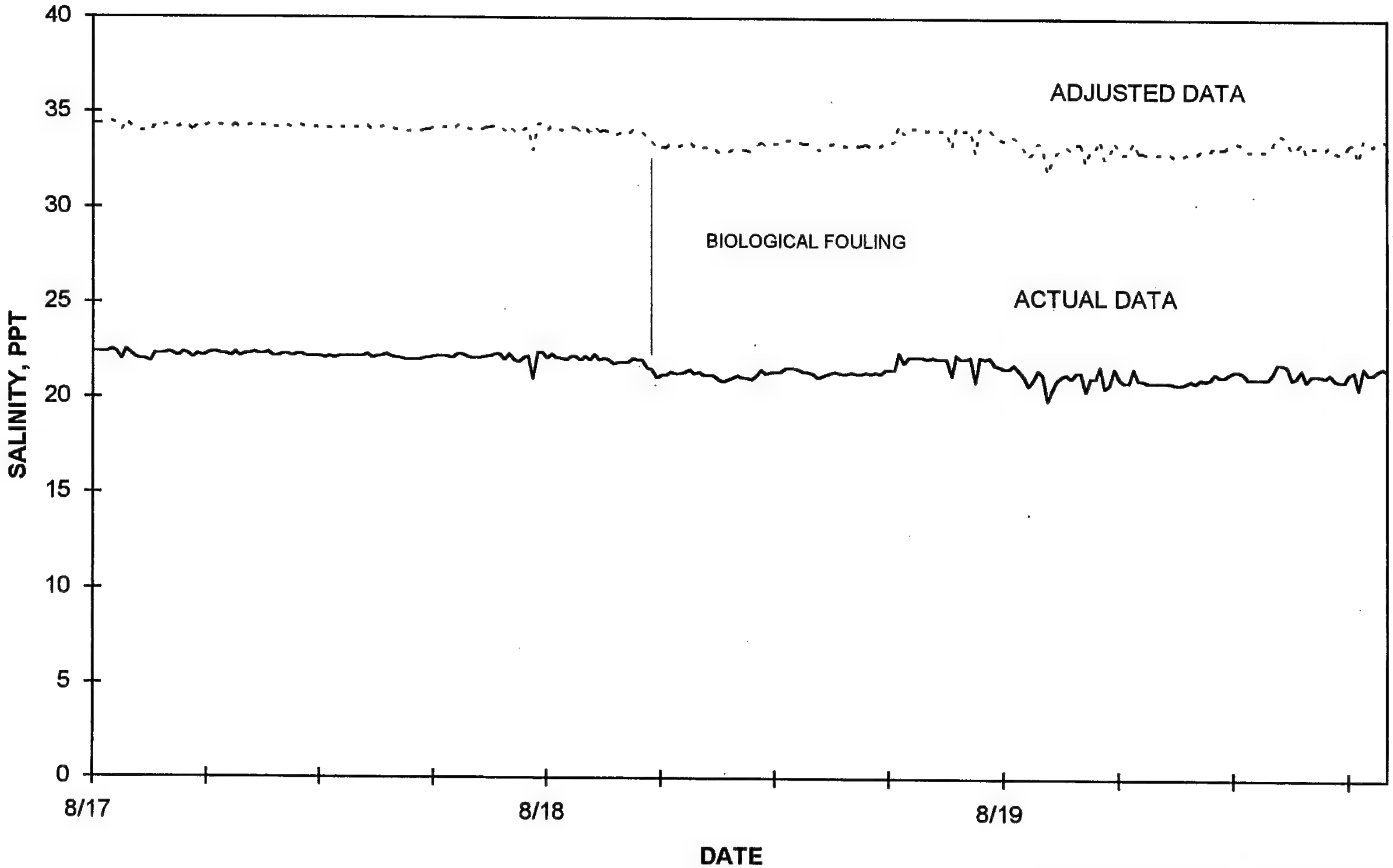
FIXED-DEPTH CURRENT METER VELOCITIES
STATION S3.0
8/17 - 19/95



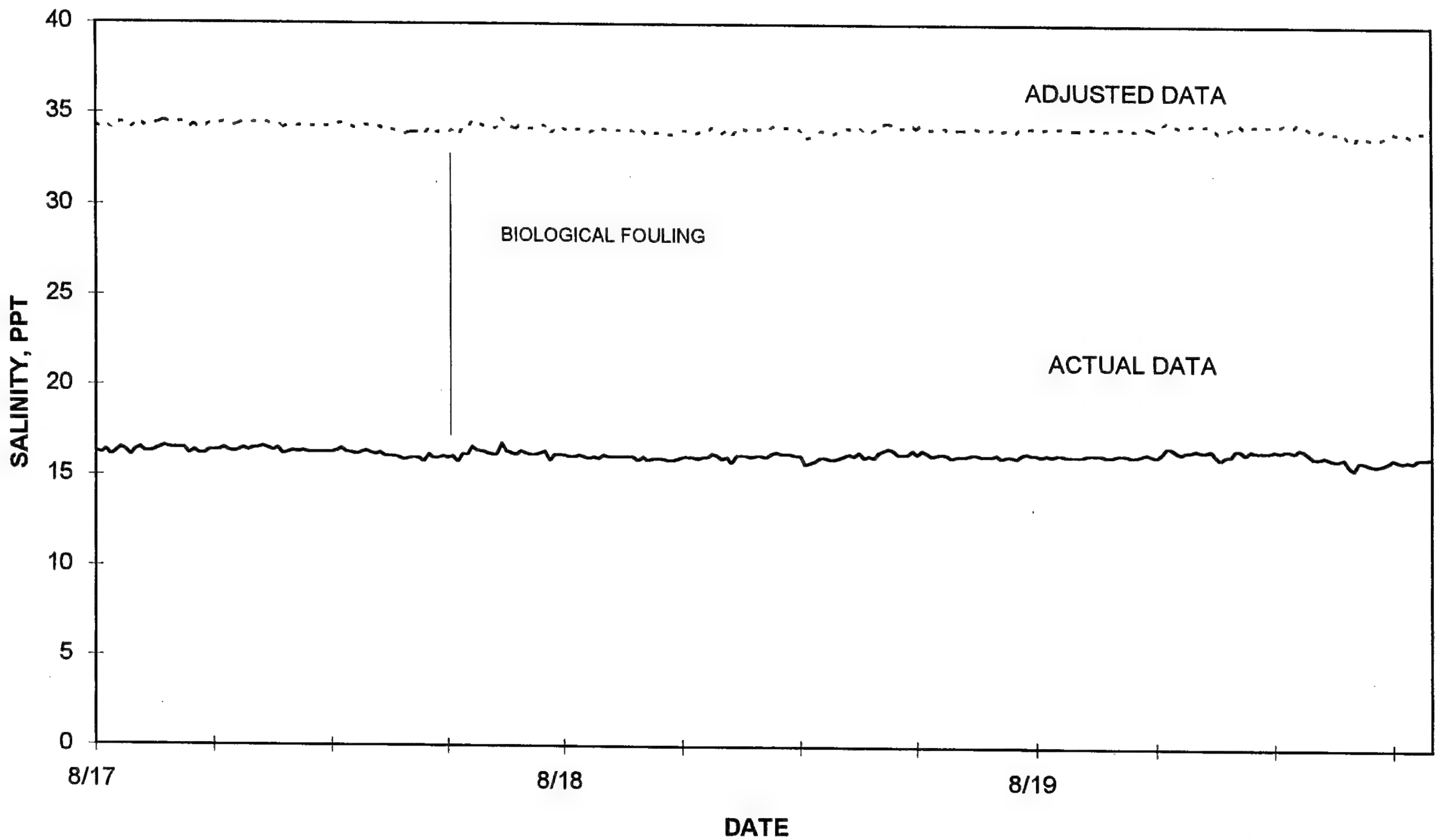
FIXED-DEPTH CURRENT METER VELOCITIES
STATION S5.0
8/17 - 19/95



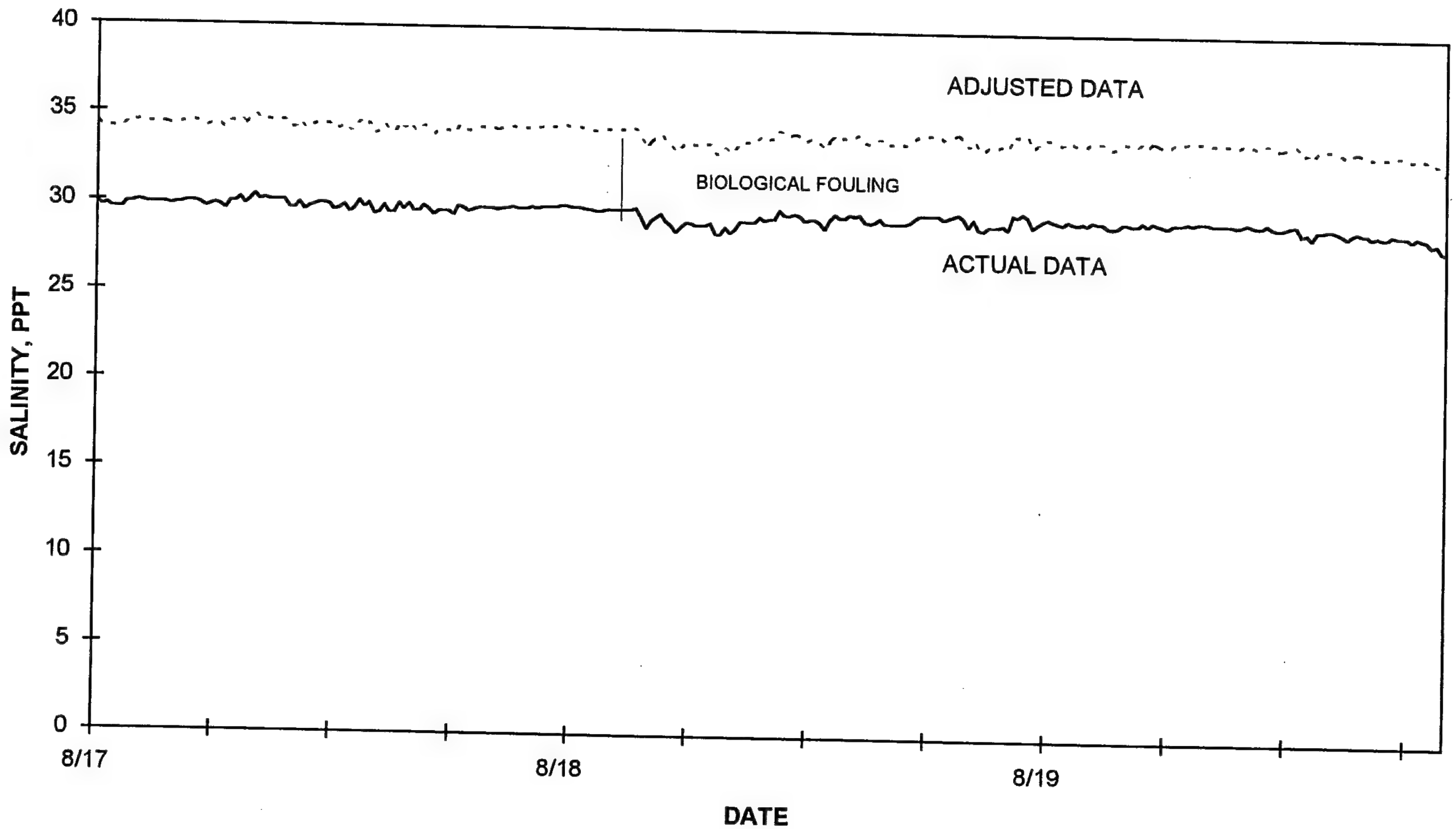
FIXED-DEPTH CURRENT METER
VELOCITIES
STATION S8.0
8/17 - 19/95



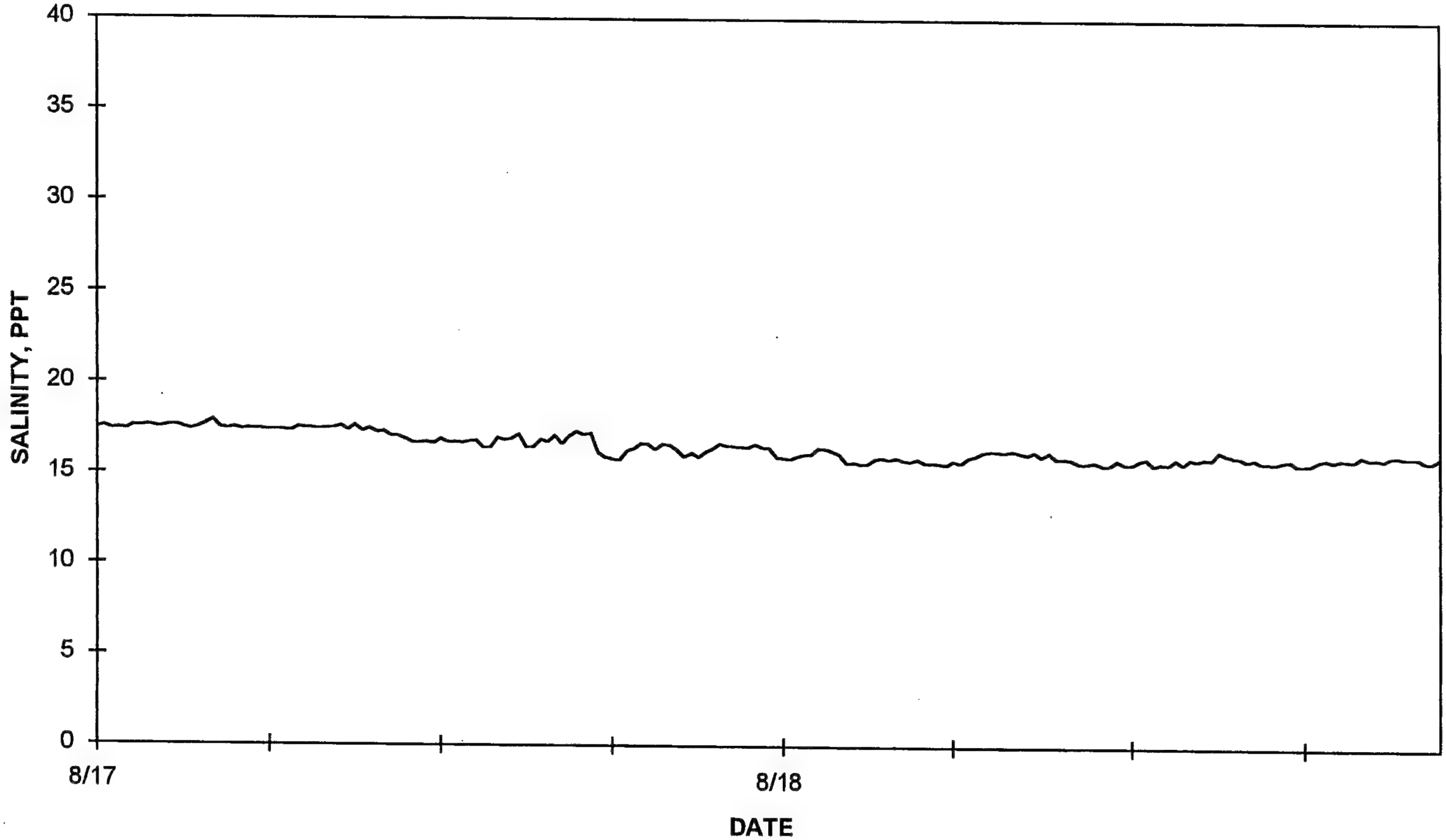
WATER-LEVEL RECORDER
SALINITY CONCENTRATIONS
STATION S1.0
8/17 - 19/95



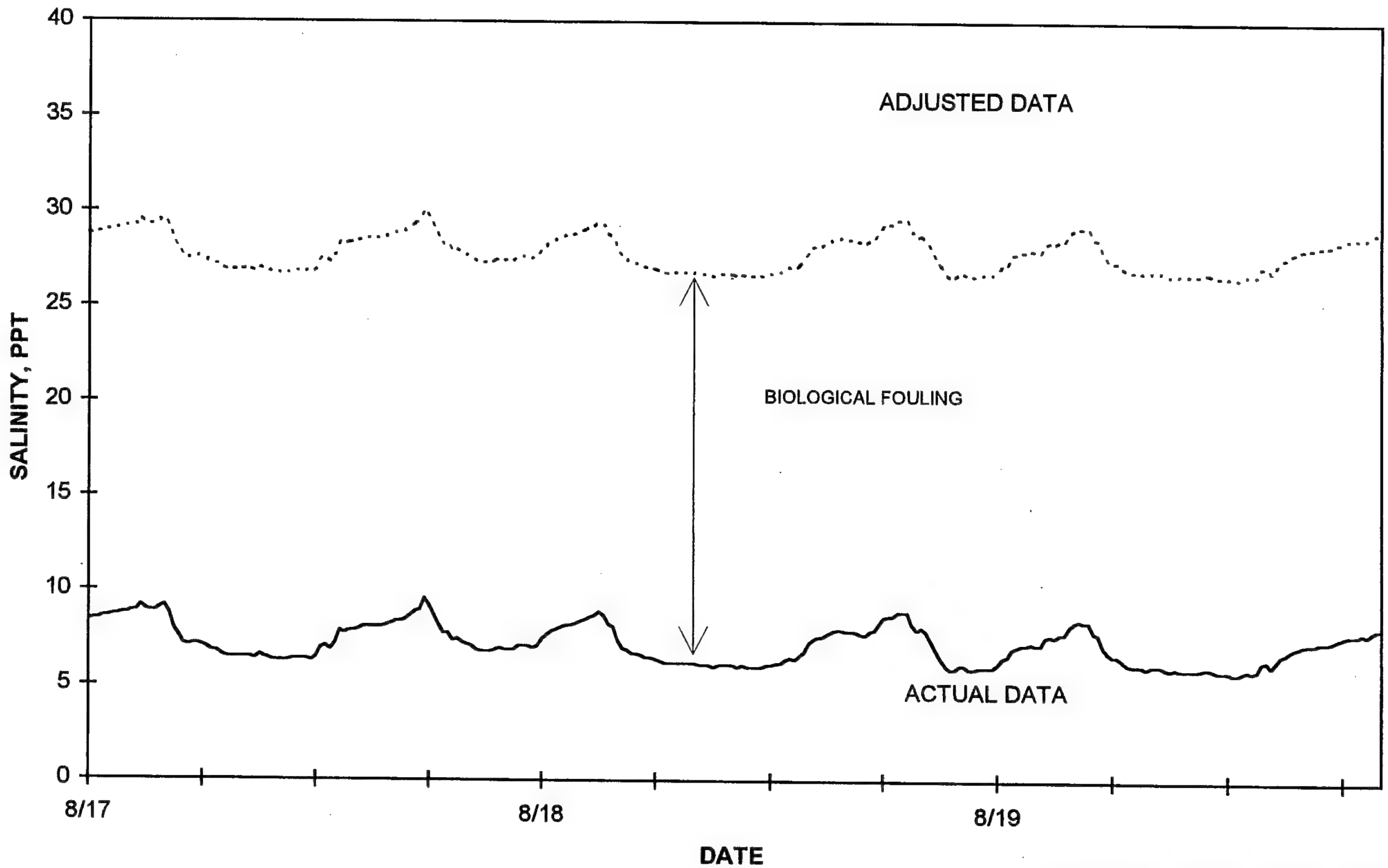
WATER-LEVEL RECORDER
SALINITY CONCENTRATIONS
STATION S2.0
8/17 - 19/95



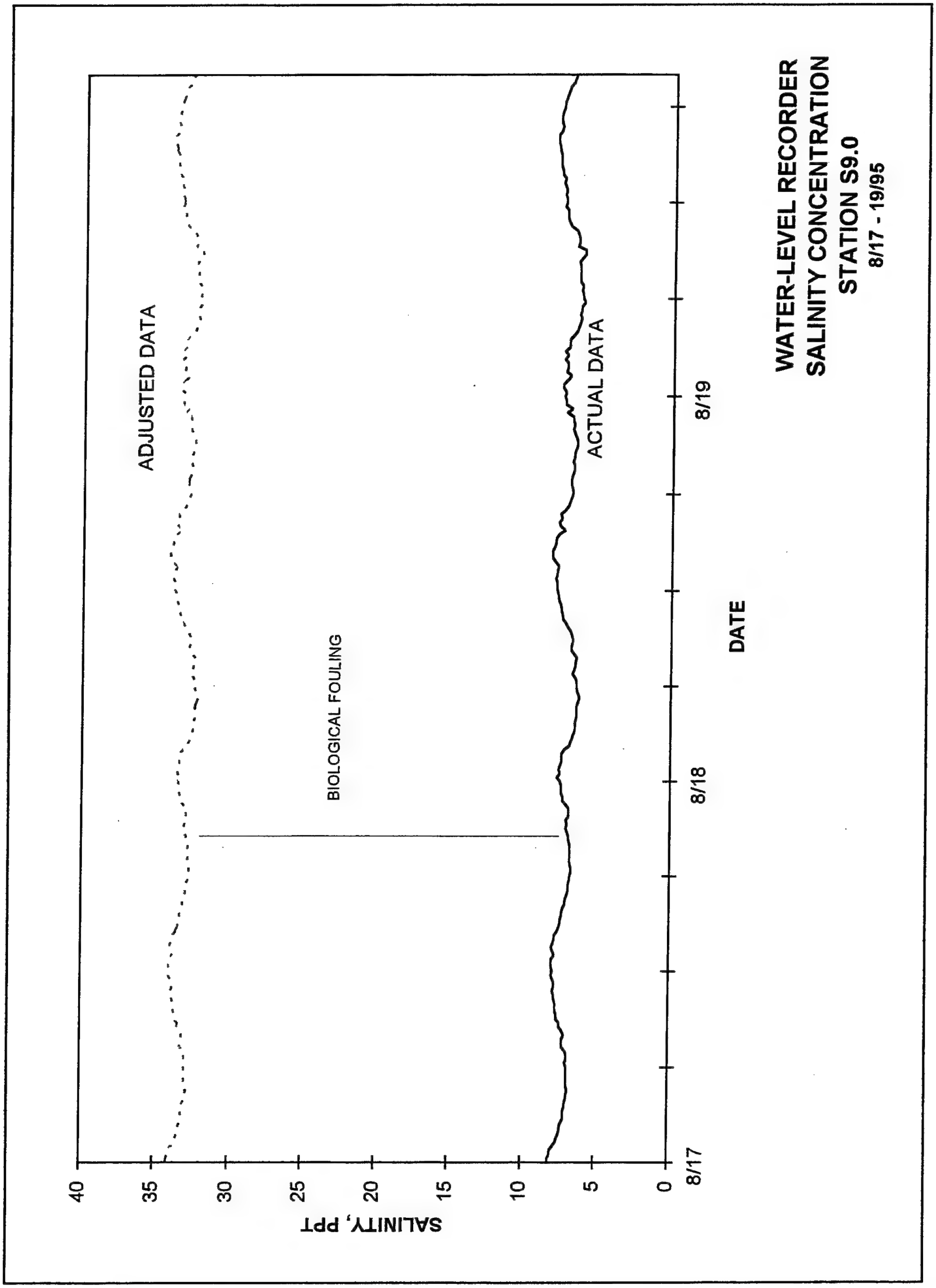
**WATER-LEVEL RECORDER
SALINITY CONCENTRATIONS
STATION S3.0**
8/17 - 19/95



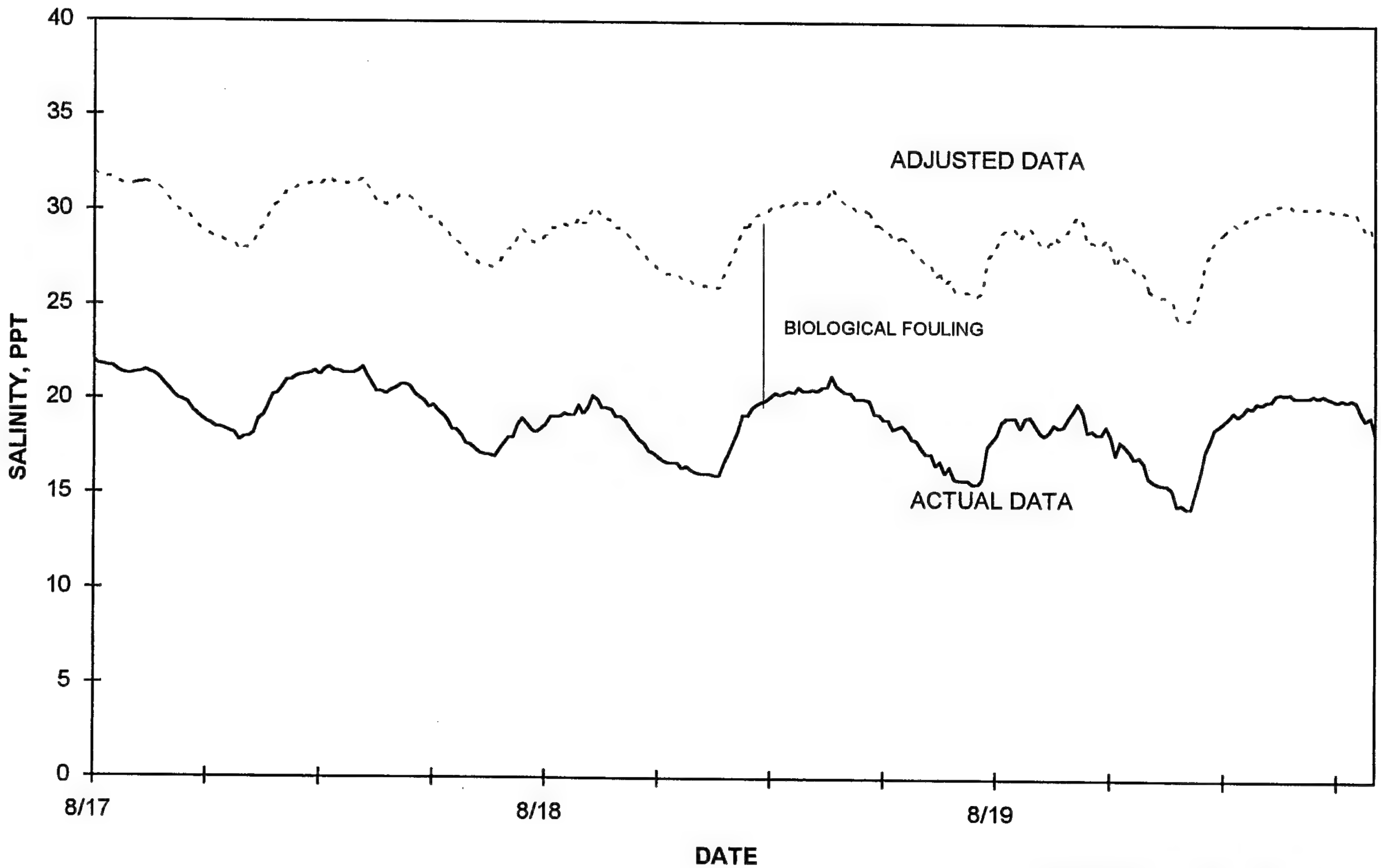
WATER-LEVEL RECORDER
SALINITY CONCENTRATIONS
STATION S6.0
8/17 - 18/95



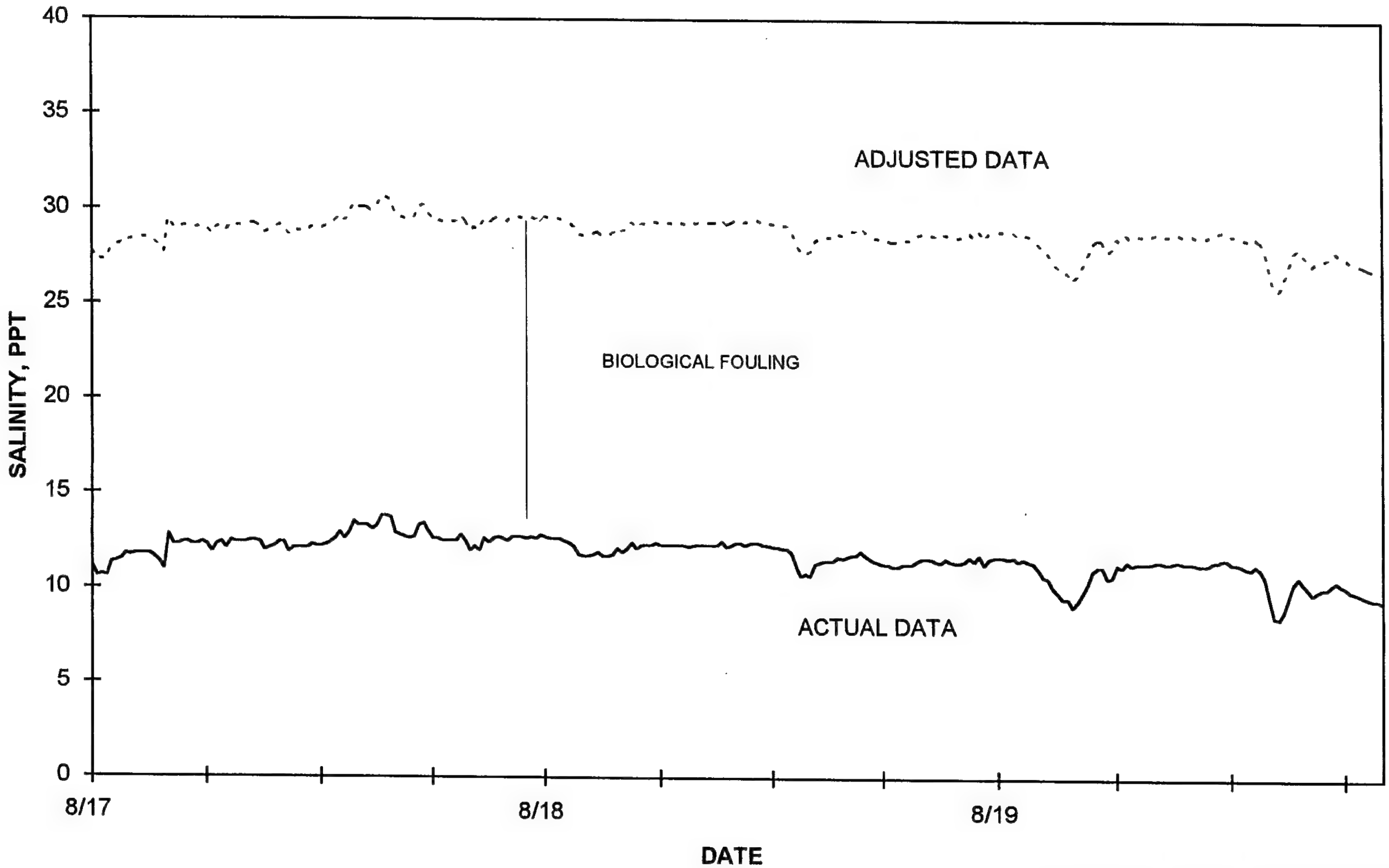
**WATER-LEVEL RECORDER
SALINITY CONCENTRATIONS
STATION S8.0**
8/17 - 19/95



WATER-LEVEL RECORDER
SALINITY CONCENTRATION
STATION S9.0
8/17 - 19/95
ADJUSTED DATA
BIOLOGICAL FOULING
ACTUAL DATA
SALINITY, PPT
0
5
10
15
20
25
30
35
40
DATE
8/17
8/18
8/19

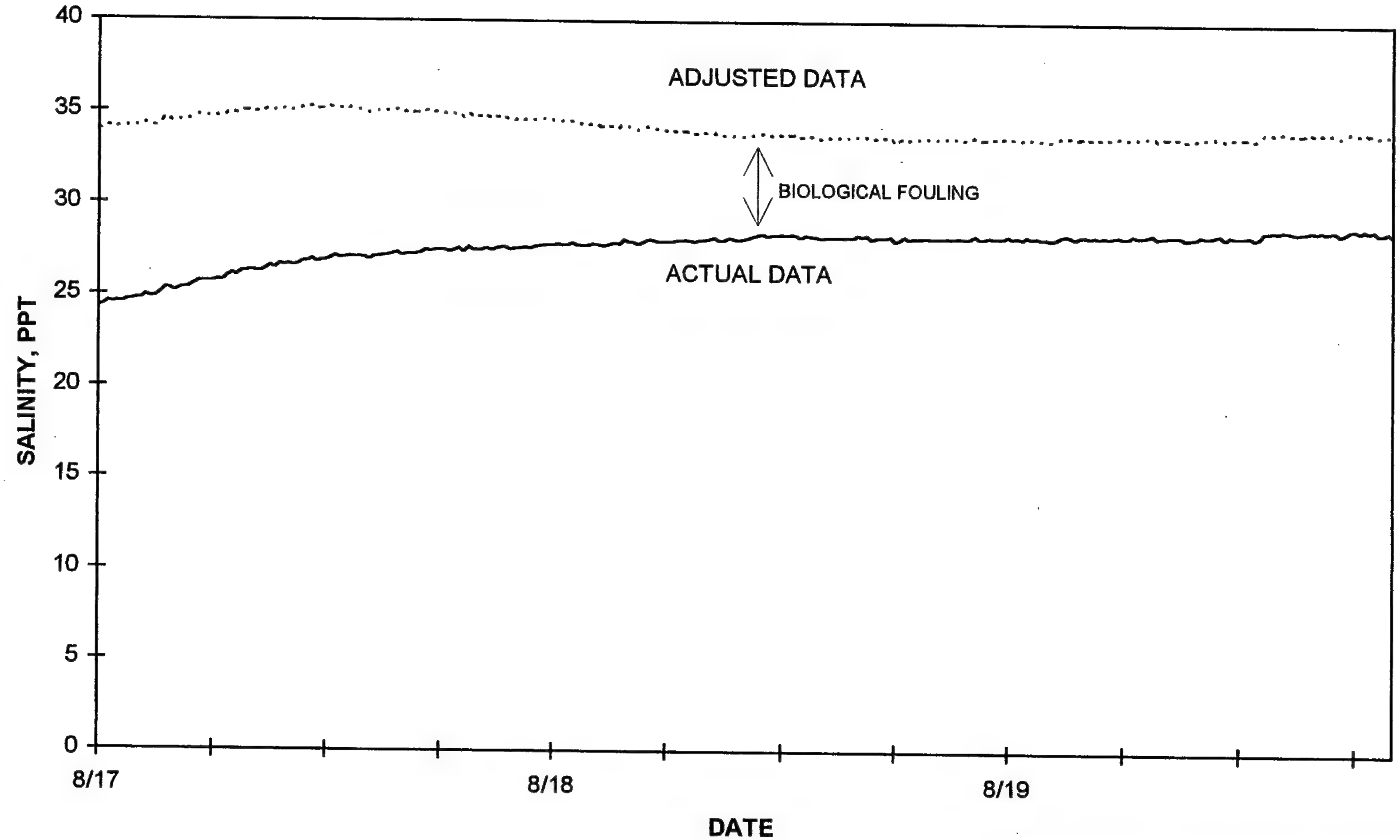


WATER-LEVEL RECORDER
SALINITY CONCENTRATIONS
STATION S10.0
8/17/95 - 8/19/95

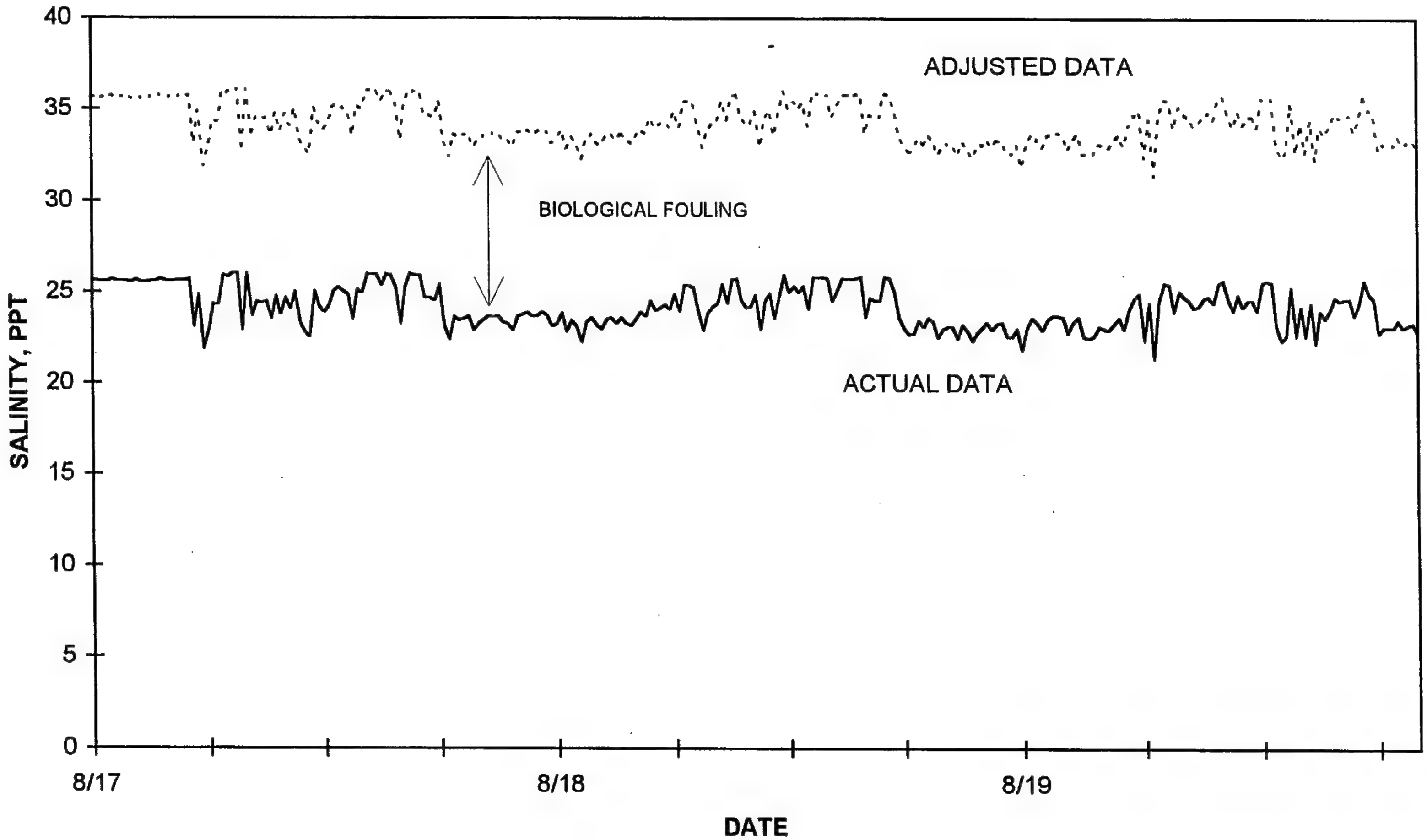


WATER-LEVEL RECORDER
SALINITY CONCENTRATIONS
STATION S11.0
8/17 - 19/95

Plate 166

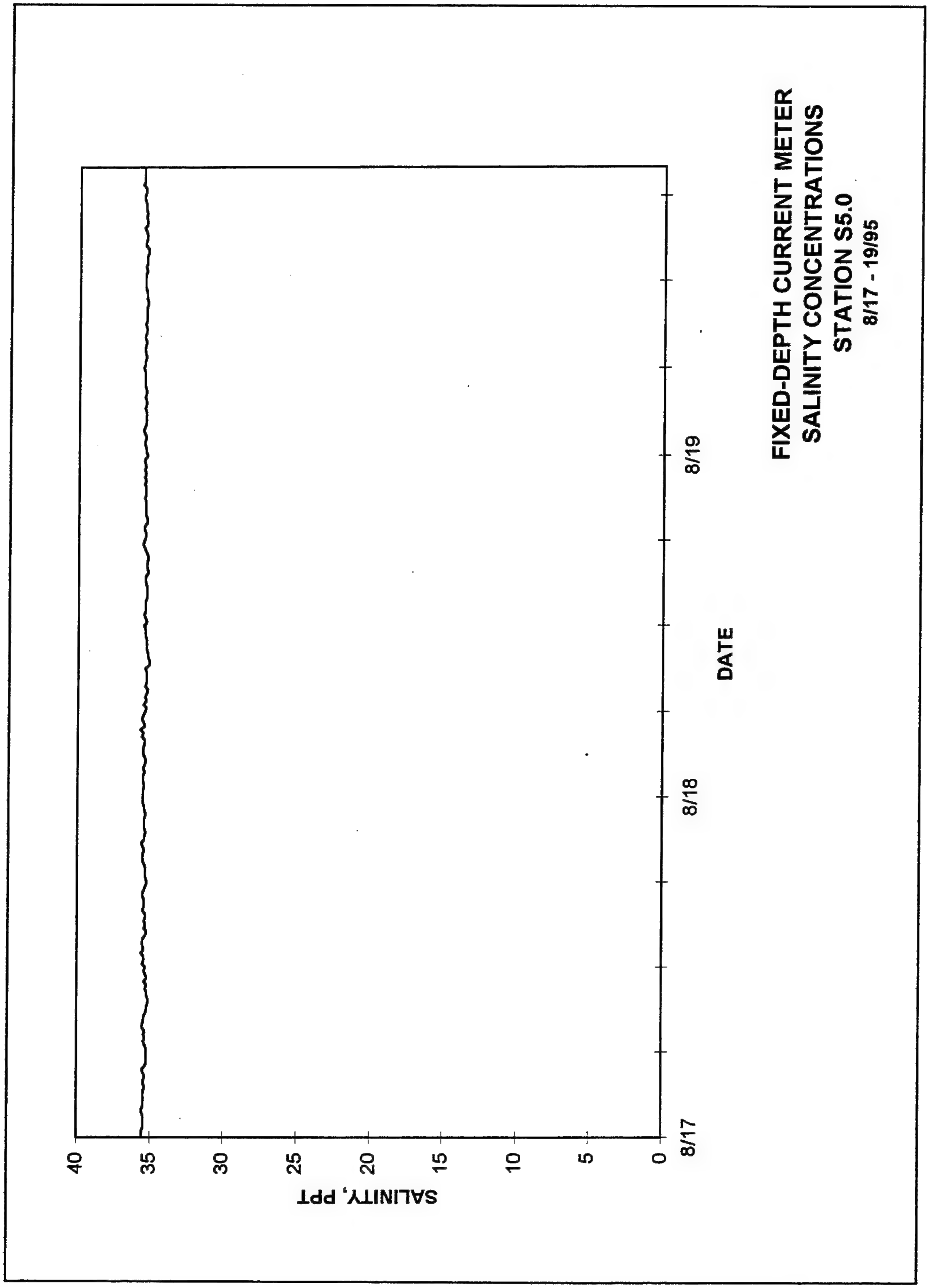


FIXED-DEPTH CURRENT METER
SALINITY CONCENTRATIONS
STATION S1.0
8/17 - 19/95

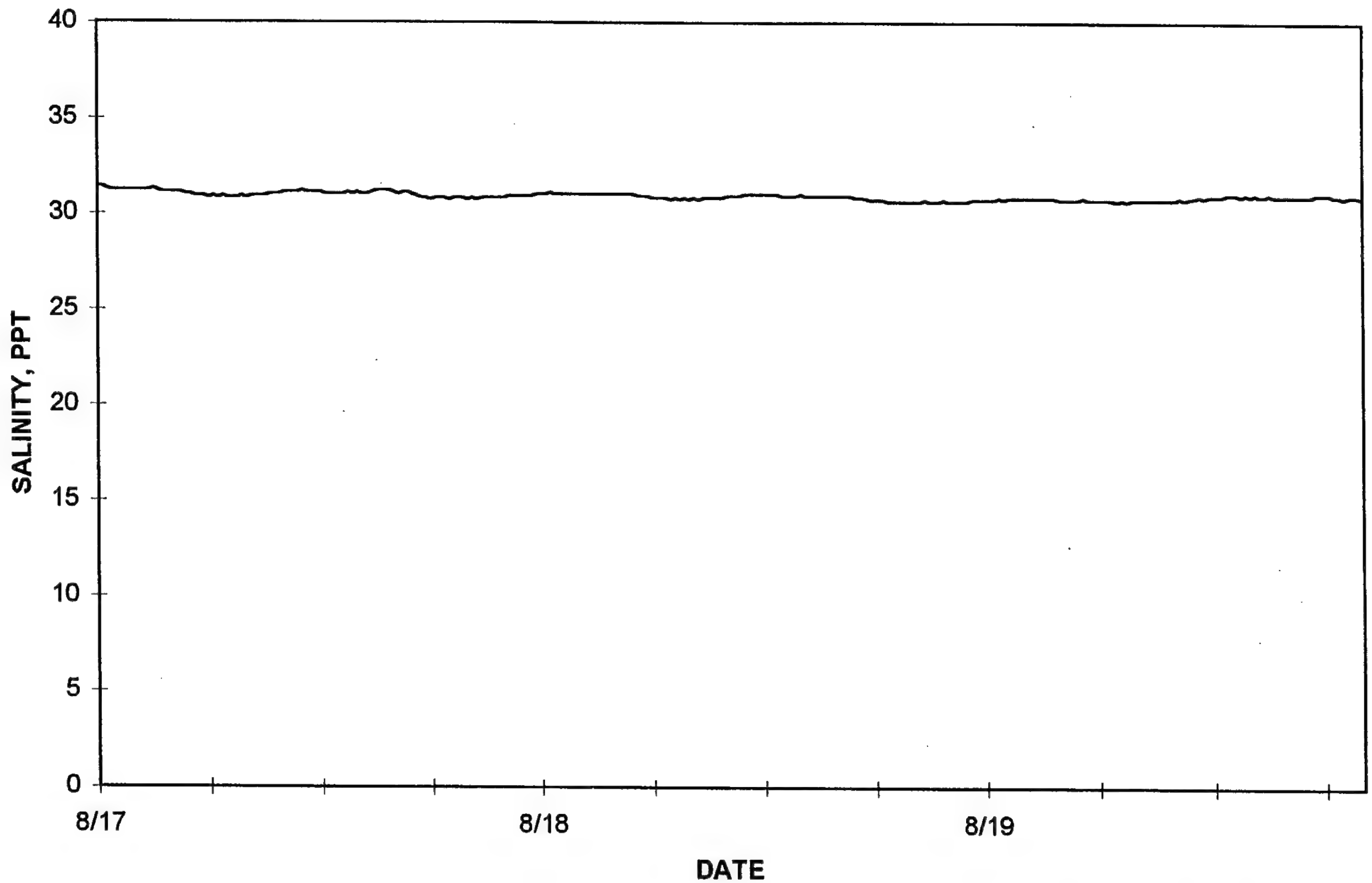


FIXED-DEPTH CURRENT METER
SALINITY CONCENTRATIONS
STATION S3.0
8/01 - 19/95

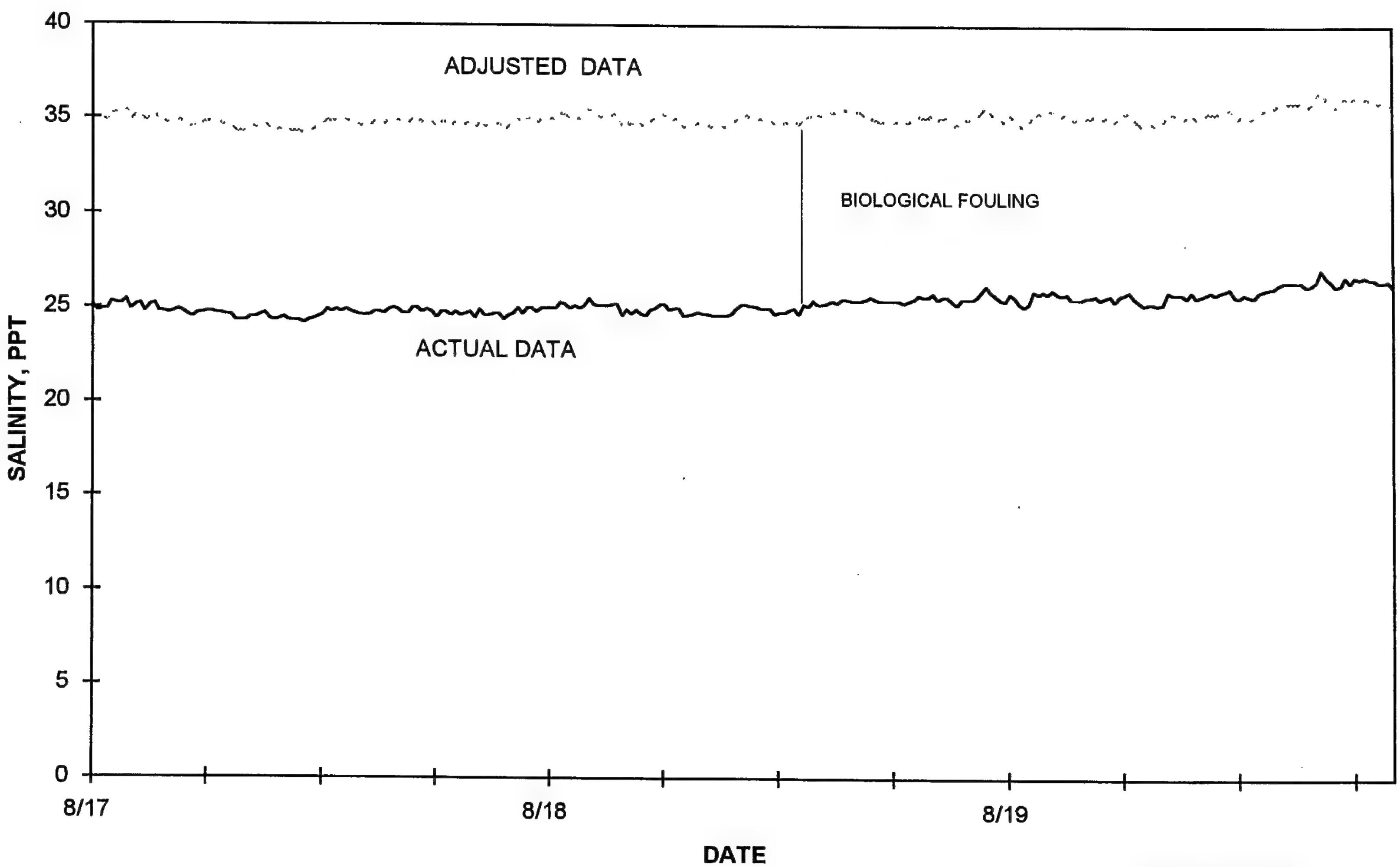
Plate 168



FIXED-DEPTH CURRENT METER
SALINITY CONCENTRATIONS
STATION S5.0
8/17 - 19/95
SALINITY, PPT
0
5
10
15
20
25
30
35
40
DATE
8/17
8/18
8/19



FIXED-DEPTH CURRENT METER
SALINITY CONCENTRATIONS
STATION S8.0
8/17 - 19/95



DATASONDE 3
SALINITY CONCENTRATIONS
STATION S1.0
8/17/95 - 8/19/95

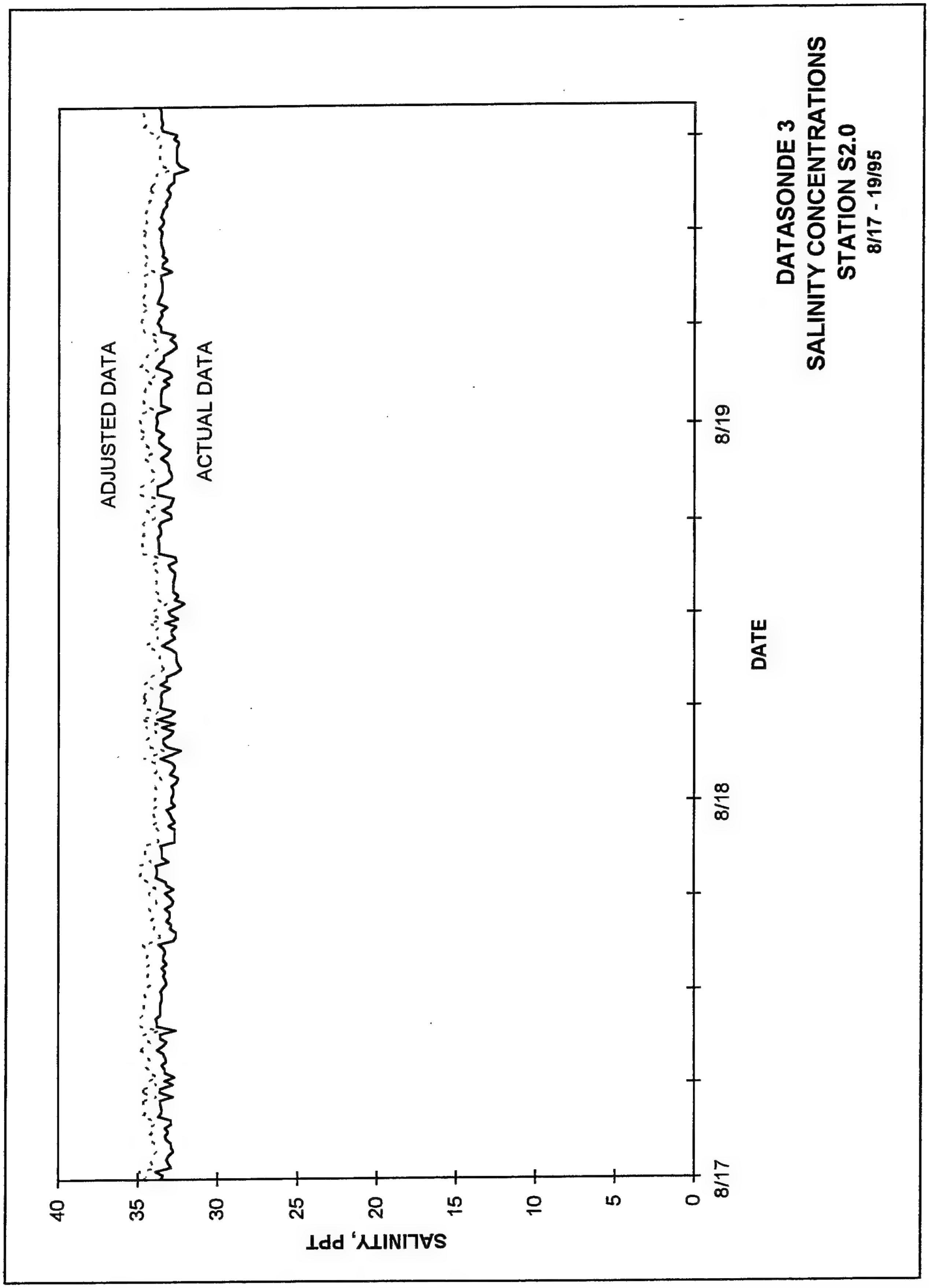

DATASONDE 3
SALINITY CONCENTRATIONS
STATION S2.0
8/17 - 19/95
ADJUSTED DATA
ACTUAL DATA
SALINITY, PPT
DATE
0
5
10
15
20
25
30
35
40
8/17
8/18
8/19

Plate 172

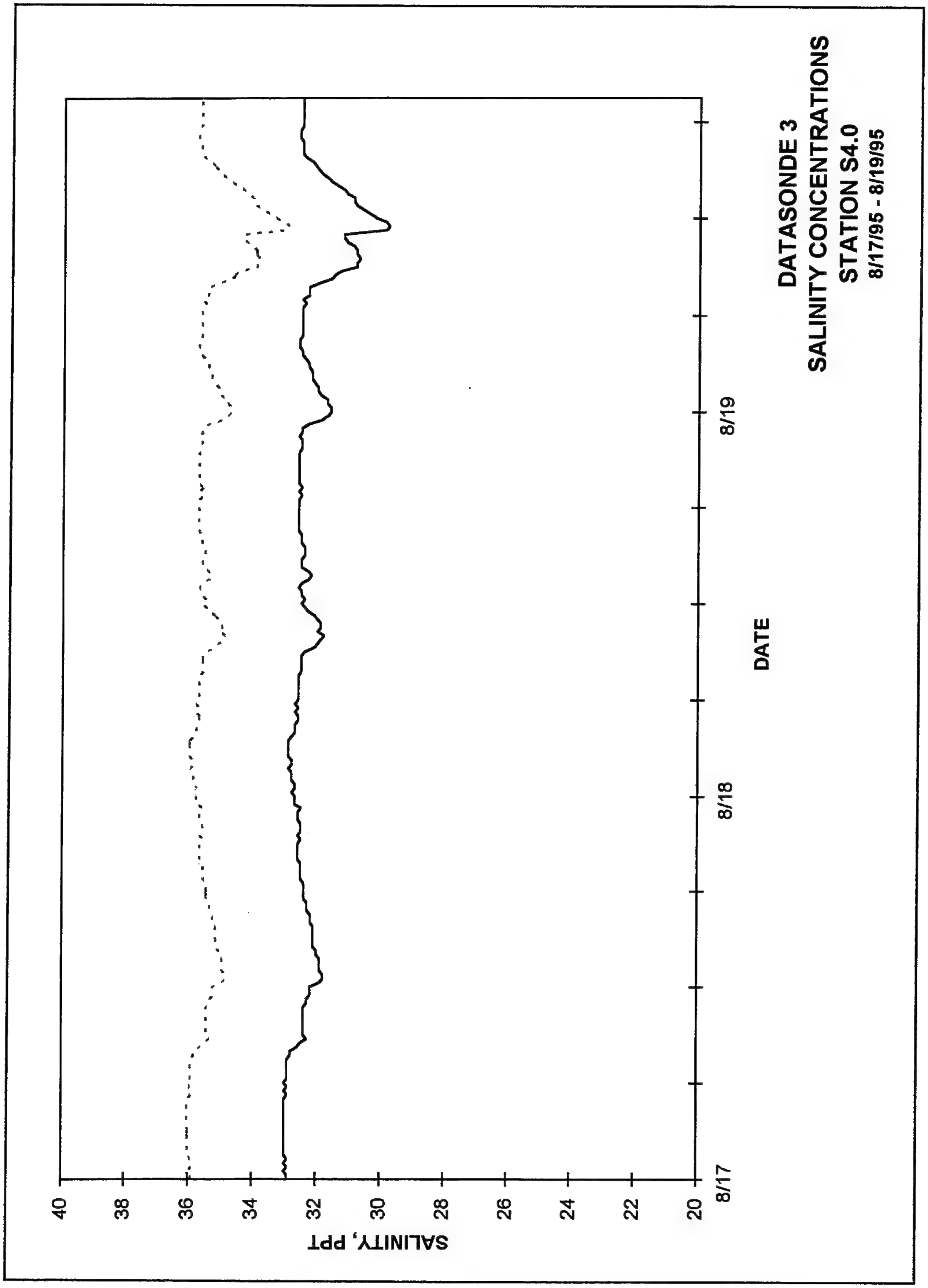

DATASONDE 3
SALINITY CONCENTRATIONS
STATION S4.0
8/17/95 - 8/19/95
SALINITY, PPT
DATE
40
38
36
34
32
30
28
26
24
22
20
8/17
8/18
8/19

Plate 173

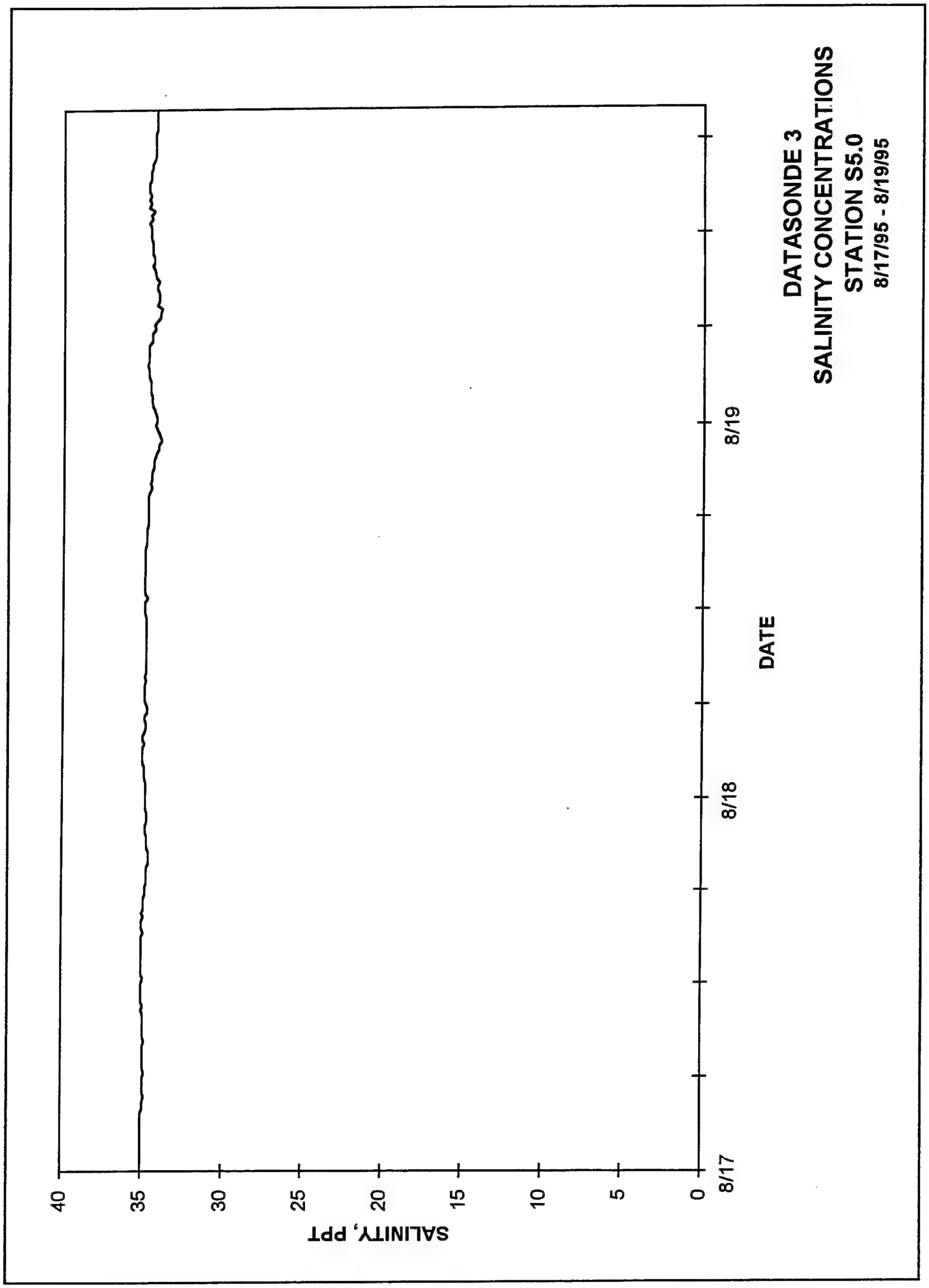

DATASONDE 3
SALINITY CONCENTRATIONS
STATION S5.0
8/17/95 - 8/19/95
SALINITY, PPT
0
5
10
15
20
25
30
35
40
DATE
8/17
8/18
8/19

Plate 174

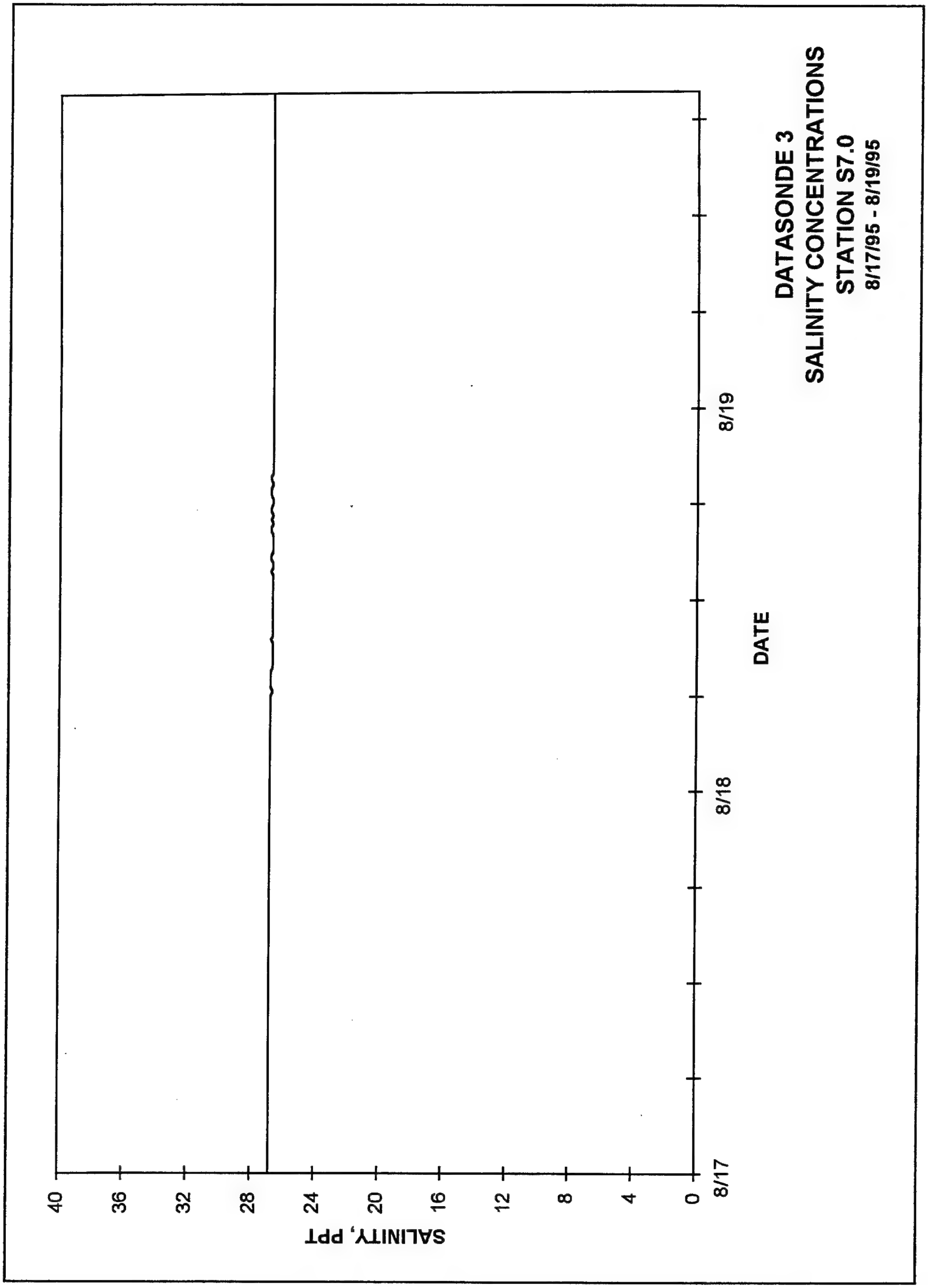

DATASONDE 3
SALINITY CONCENTRATIONS
STATION S7.0
8/17/95 - 8/19/95
SALINITY, PPT
0
4
8
12
16
20
24
28
32
36
40
DATE
8/17
8/18
8/19

Plate 175

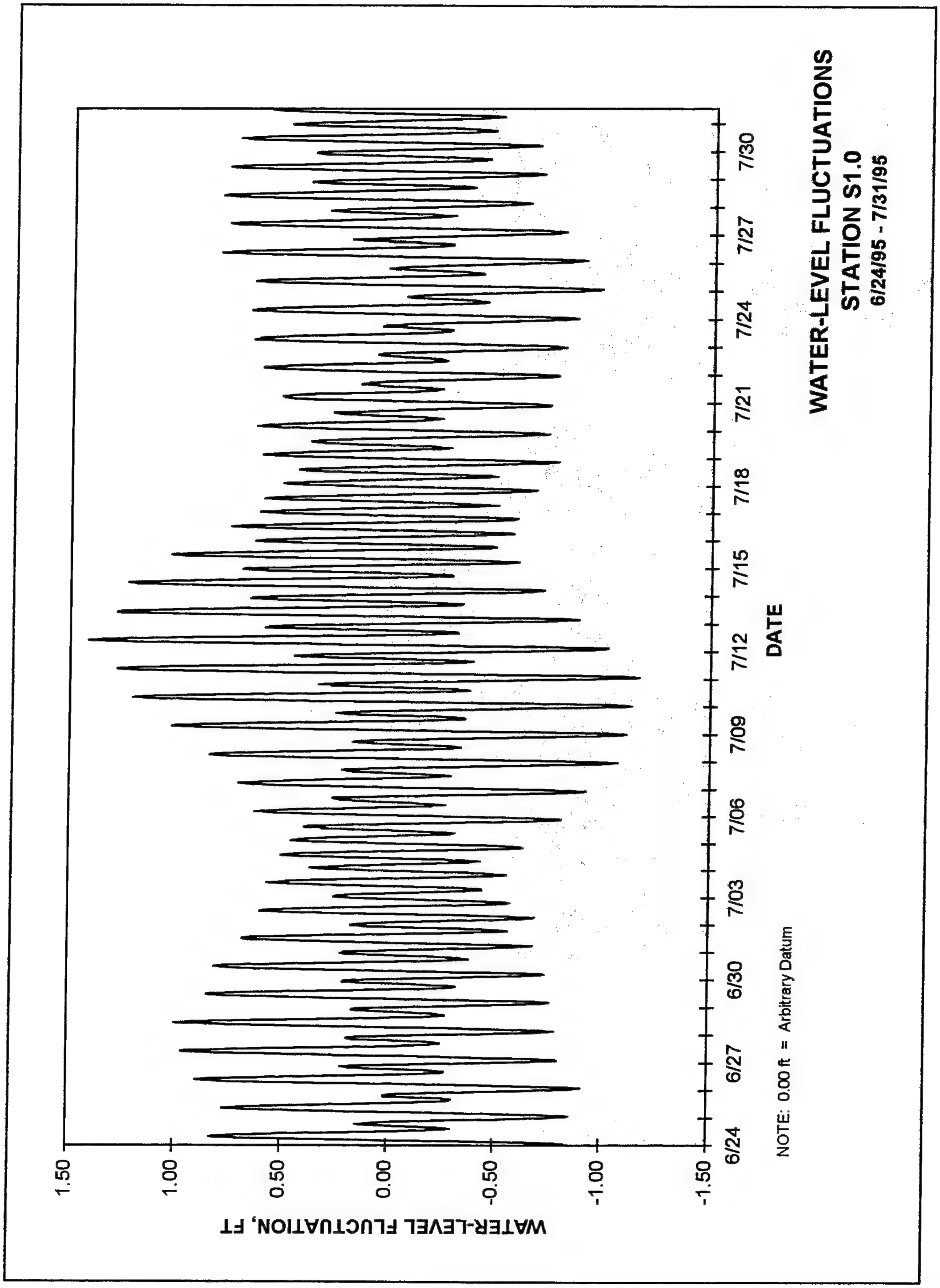
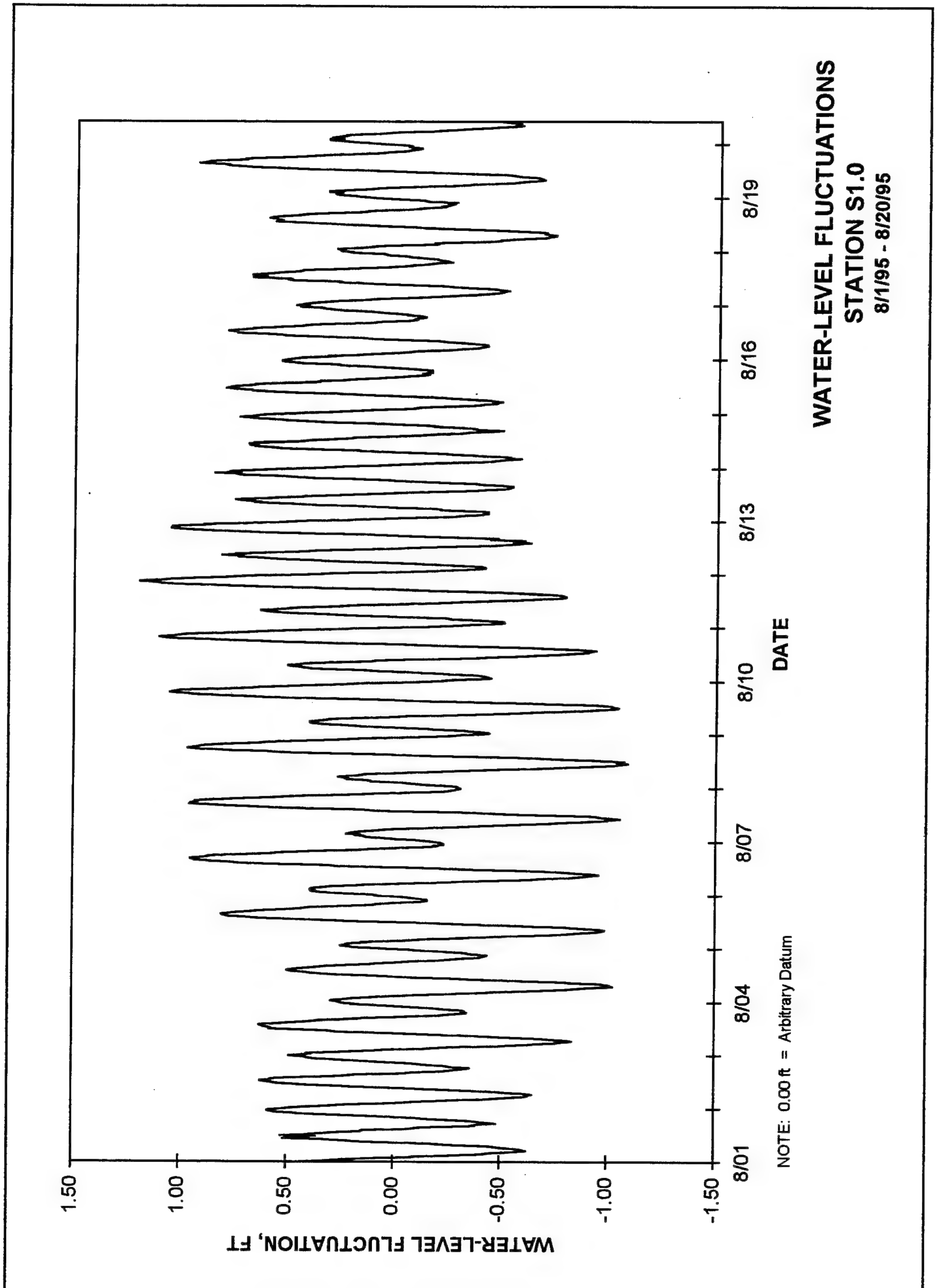
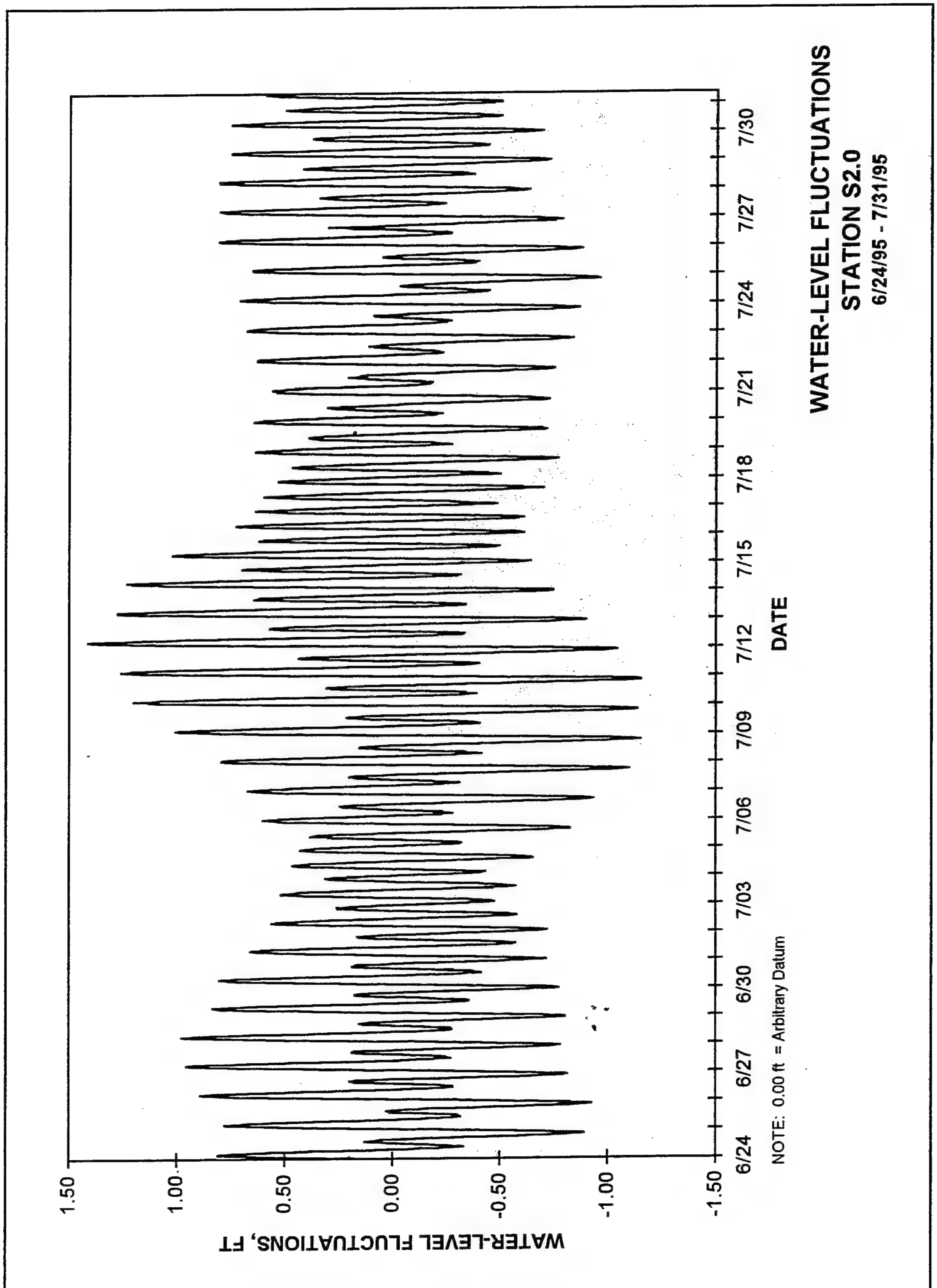

WATER-LEVEL FLUCTUATIONS
STATION S1.0
6/24/95 - 7/31/95
WATER-LEVEL FLUCTUATION, FT
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
DATE
6/24
6/27
6/30
7/03
7/06
7/09
7/12
7/15
7/18
7/21
7/24
7/27
7/30
NOTE: 0.00 ft = Arbitrary Datum

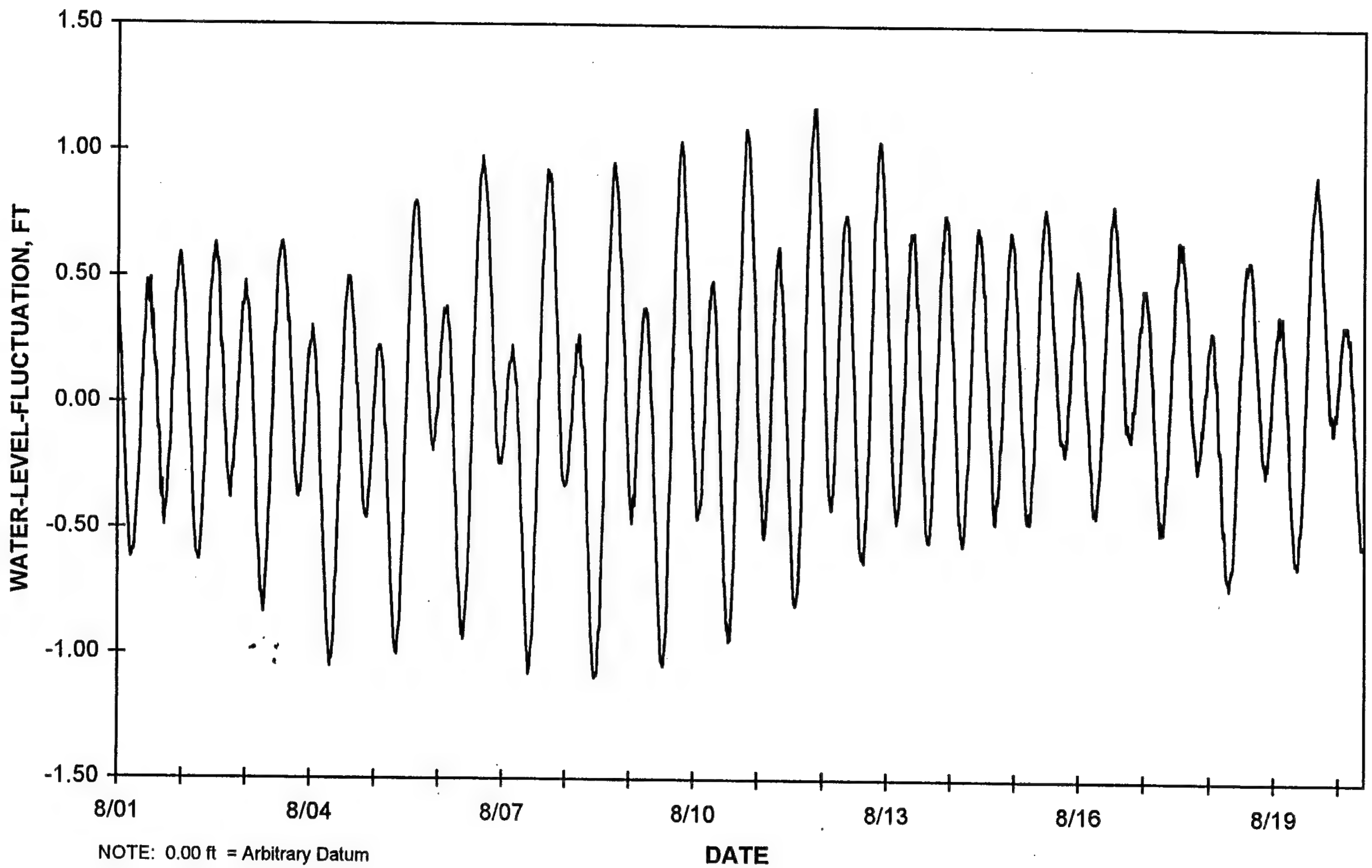
Plate 176



WATER-LEVEL FLUCTUATIONS
STATION S1.0
8/1/95 - 8/20/95
WATER-LEVEL FLUCTUATION, FT
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
8/01
8/04
8/07
8/10
8/13
8/16
8/19
DATE
NOTE: 0.00 ft = Arbitrary Datum



WATER-LEVEL FLUCTUATIONS
STATION S2.0
6/24/95 - 7/31/95
WATER-LEVEL FLUCTUATIONS, FT
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
6/24
6/27
6/30
7/03
7/06
7/09
7/12
7/15
7/18
7/21
7/24
7/27
7/30
DATE
NOTE: 0.00 ft = Arbitrary Datum



NOTE: 0.00 ft = Arbitrary Datum

WATER-LEVEL FLUCTUATIONS
STATION S2.0
8/1/95 - 8/20/95

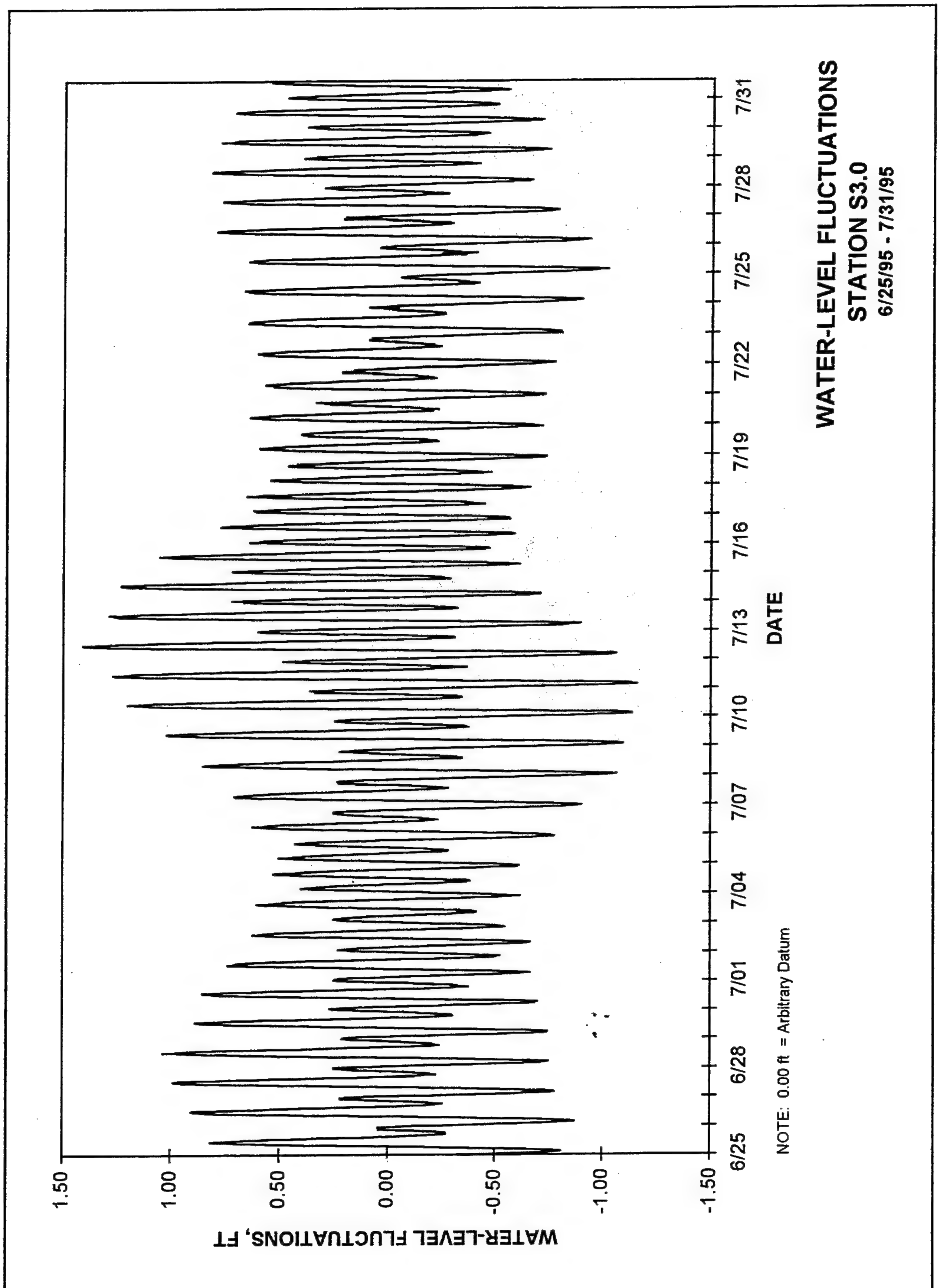
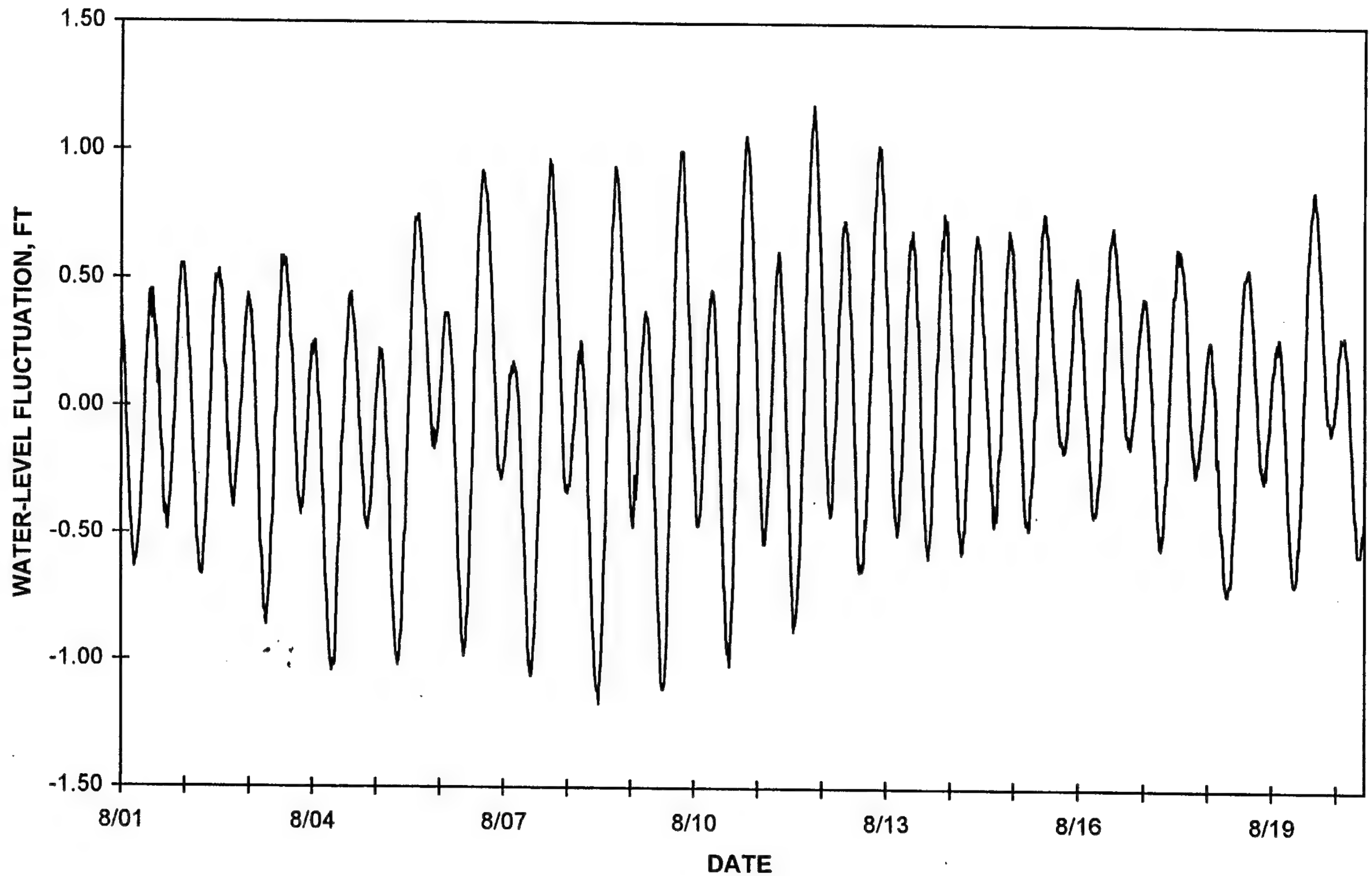
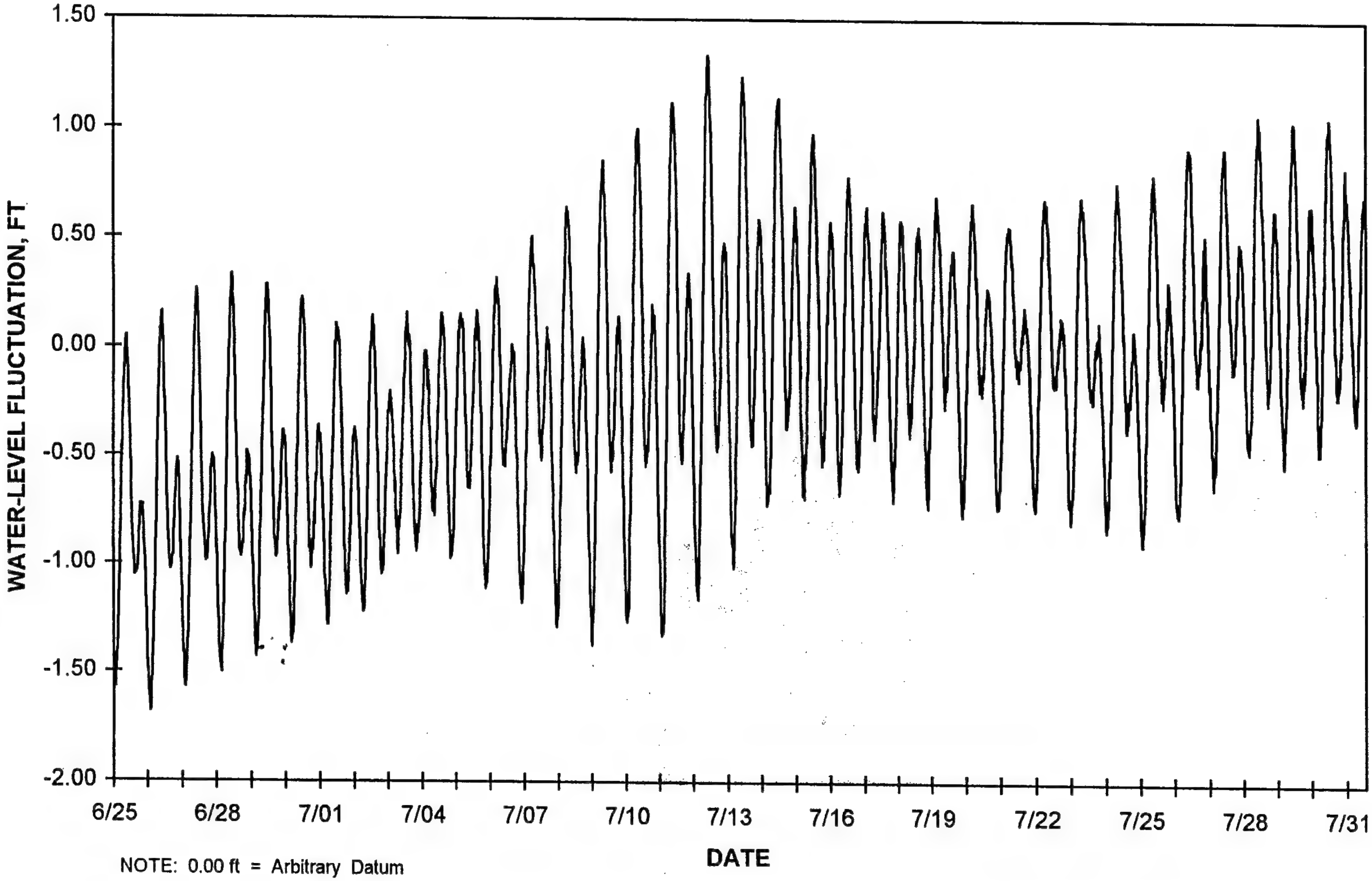

WATER-LEVEL FLUCTUATIONS
STATION S3.0
6/25/95 - 7/31/95
WATER-LEVEL FLUCTUATIONS, FT
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
DATE
6/25
6/28
7/01
7/04
7/07
7/10
7/13
7/16
7/19
7/22
7/25
7/28
7/31
NOTE: 0.00 ft = Arbitrary Datum

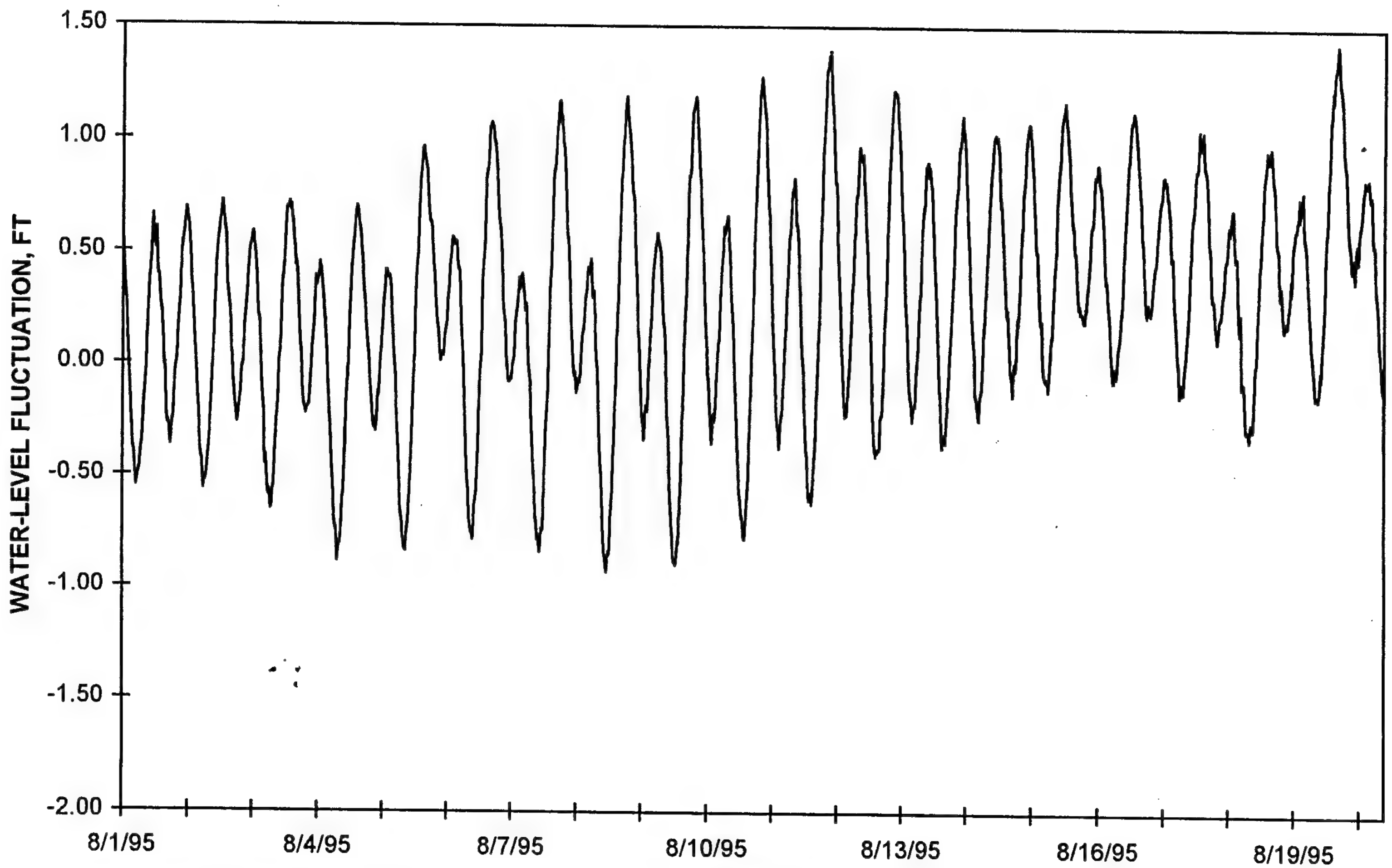
Plate 180



WATER-LEVEL FLUCTUATIONS
STATION S3.0
8/1/95 - 8/20/95

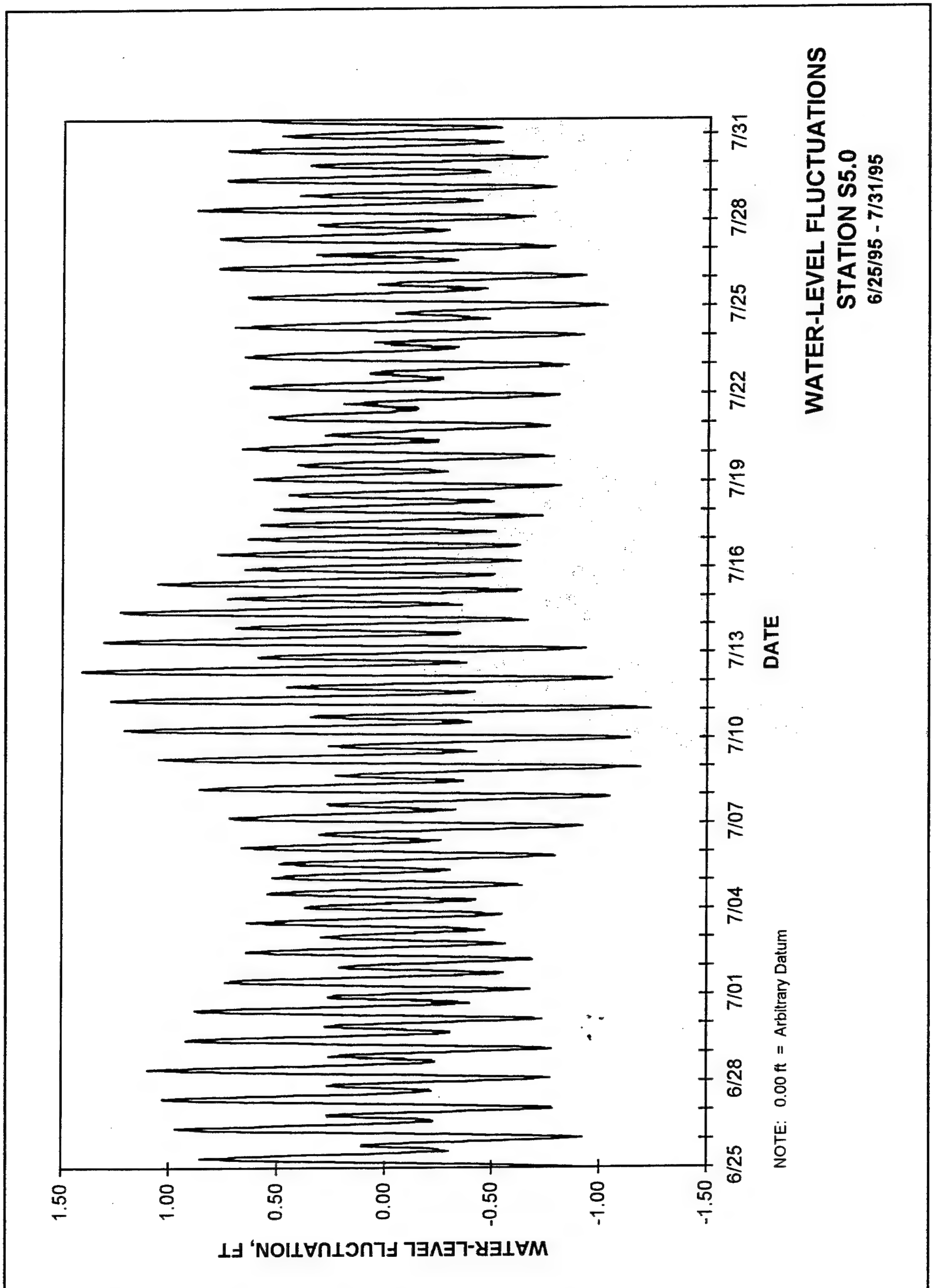


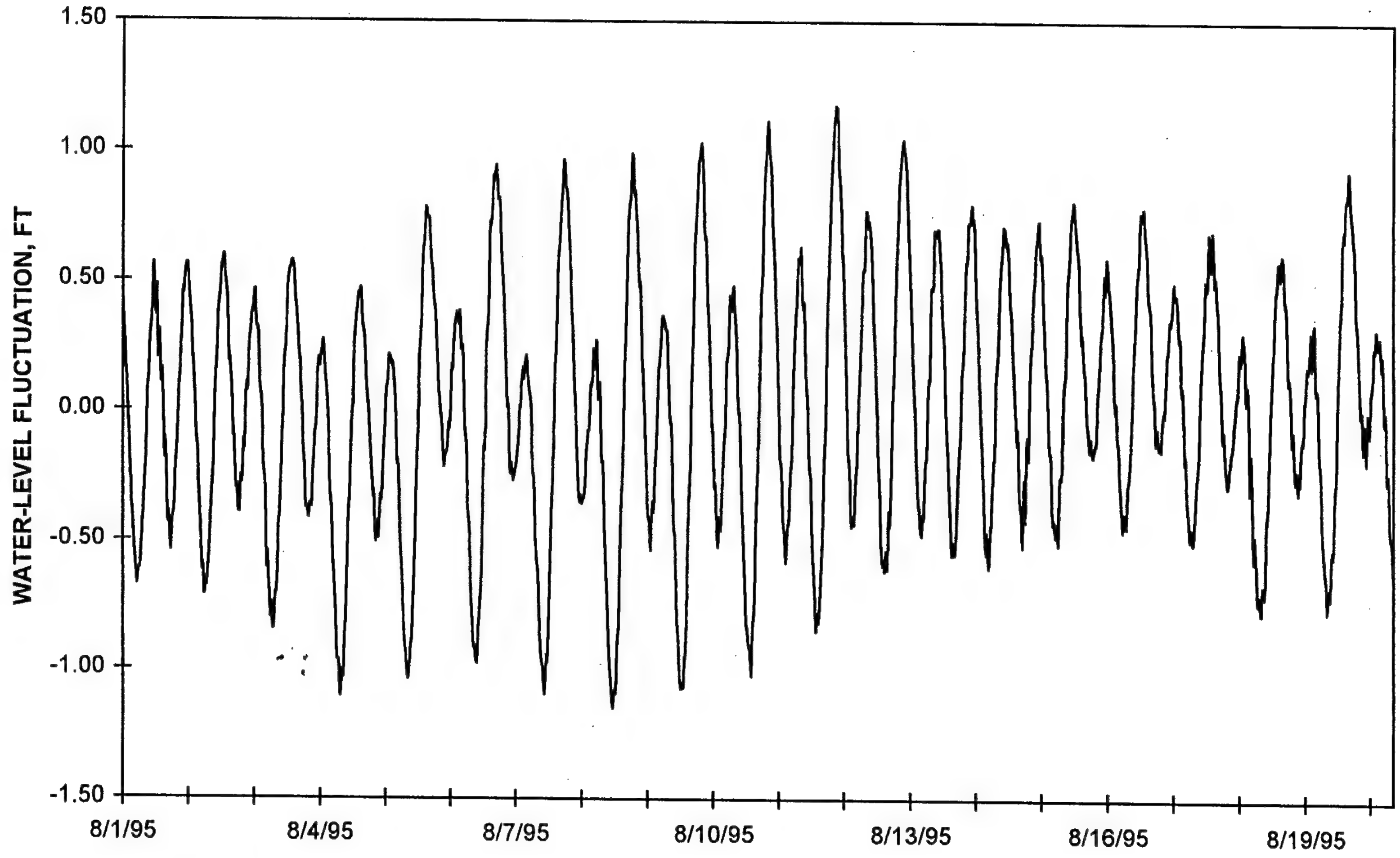
WATER-LEVEL FLUCTUATIONS
STATION S4.0
6/25/95 - 7/31/95



NOTE: 0.00 ft = Arbitrary Datum

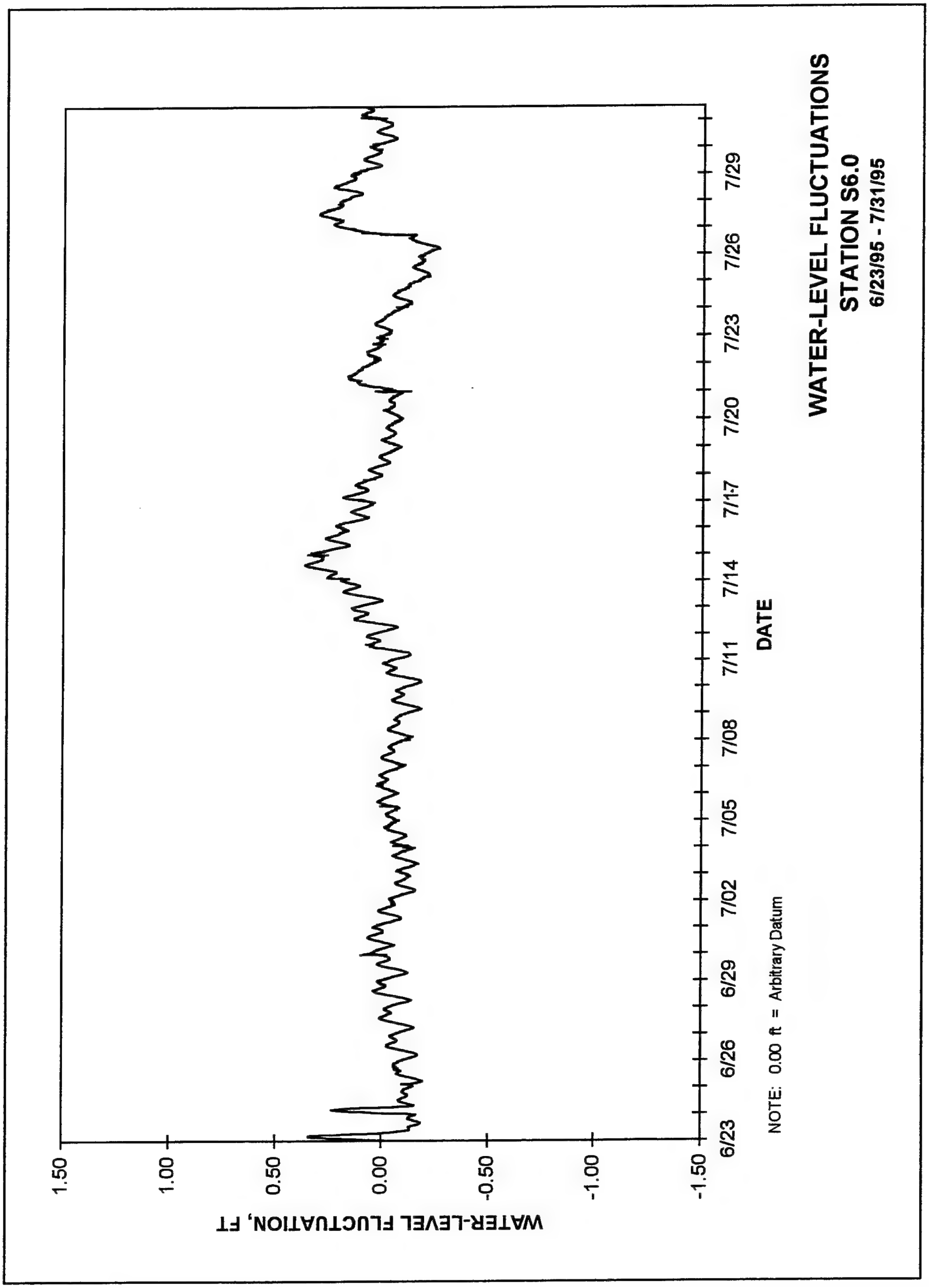
WATER-LEVEL FLUCTUATIONS
STATION S4.0
8/1/95 - 8/20/95


WATER-LEVEL FLUCTUATIONS
STATION S5.0
6/25/95 - 7/31/95
WATER-LEVEL FLUCTUATION, FT
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
DATE
6/25
6/28
7/01
7/04
7/07
7/10
7/13
7/16
7/19
7/22
7/25
7/28
7/31
NOTE: 0.00 ft = Arbitrary Datum



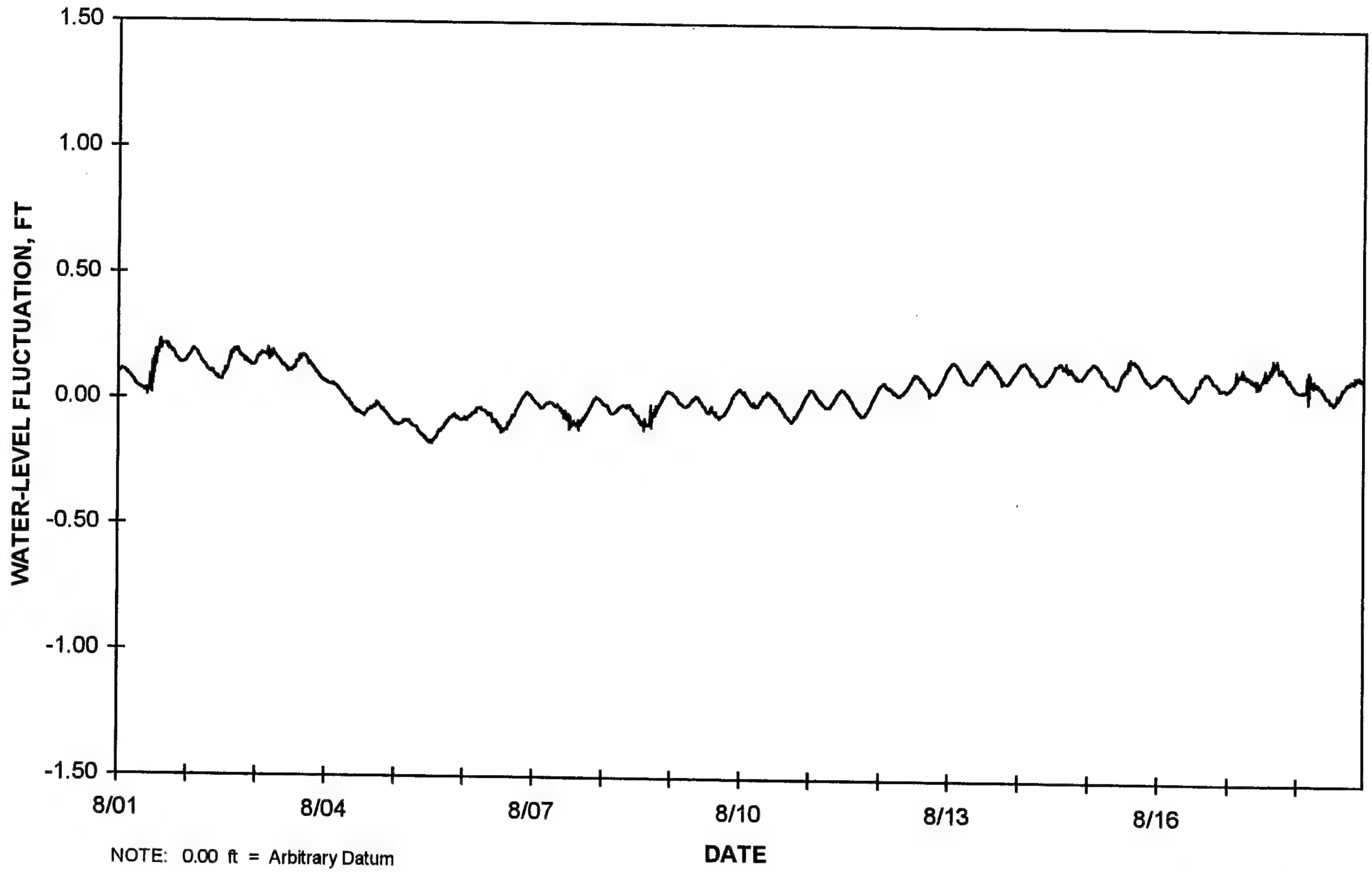
NOTE: 0.00 ft = Arbitrary Datum

WATER-LEVEL FLUCTUATIONS
STATION S5.0
8/1/95 - 8/20/95



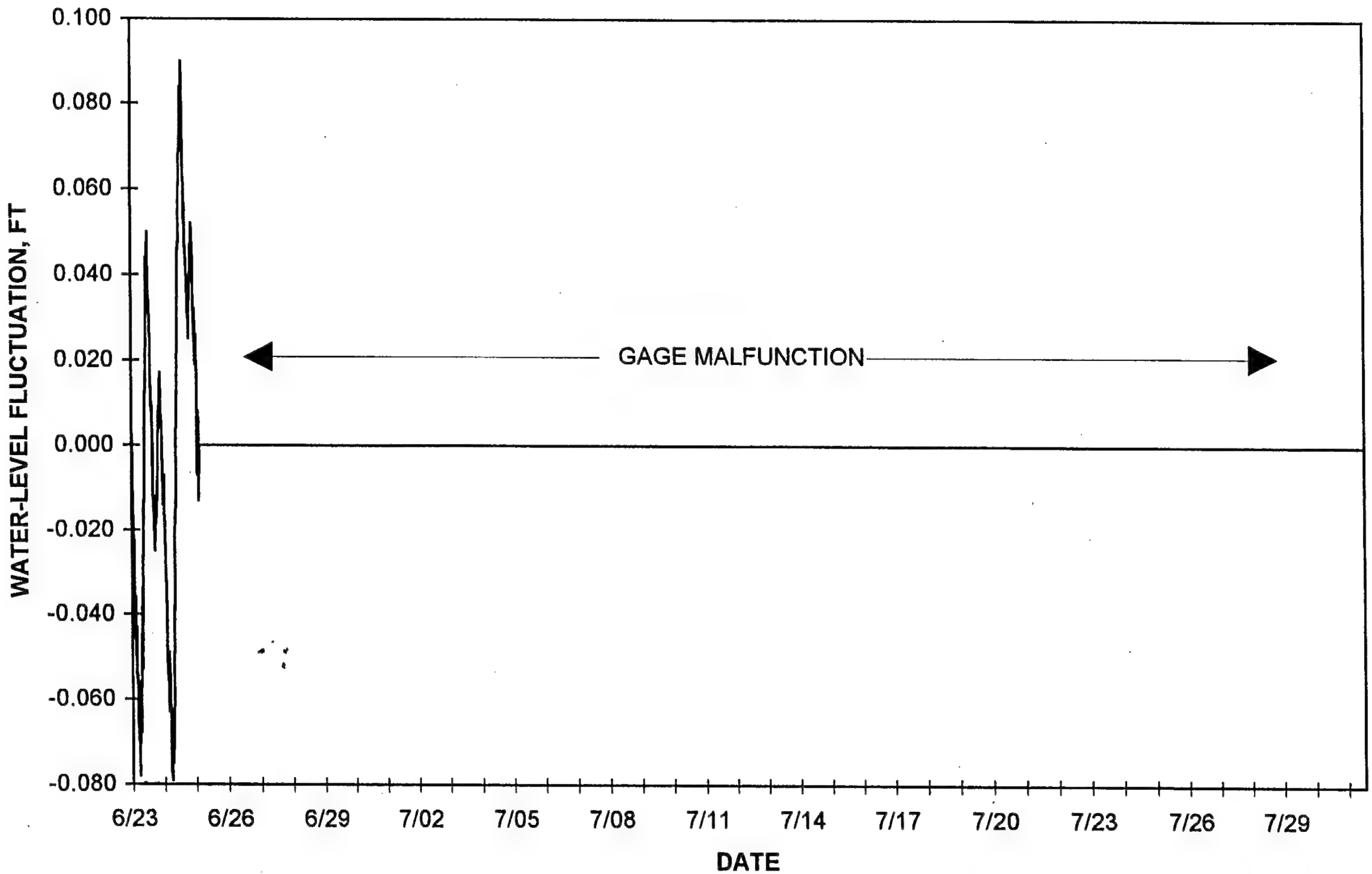
WATER-LEVEL FLUCTUATIONS
STATION S6.0
6/23/95 - 7/31/95
WATER-LEVEL FLUCTUATION, FT
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
DATE
6/23
6/26
6/29
7/02
7/05
7/08
7/11
7/14
7/17
7/20
7/23
7/26
7/29
NOTE: 0.00 ft = Arbitrary Datum

Plate 186

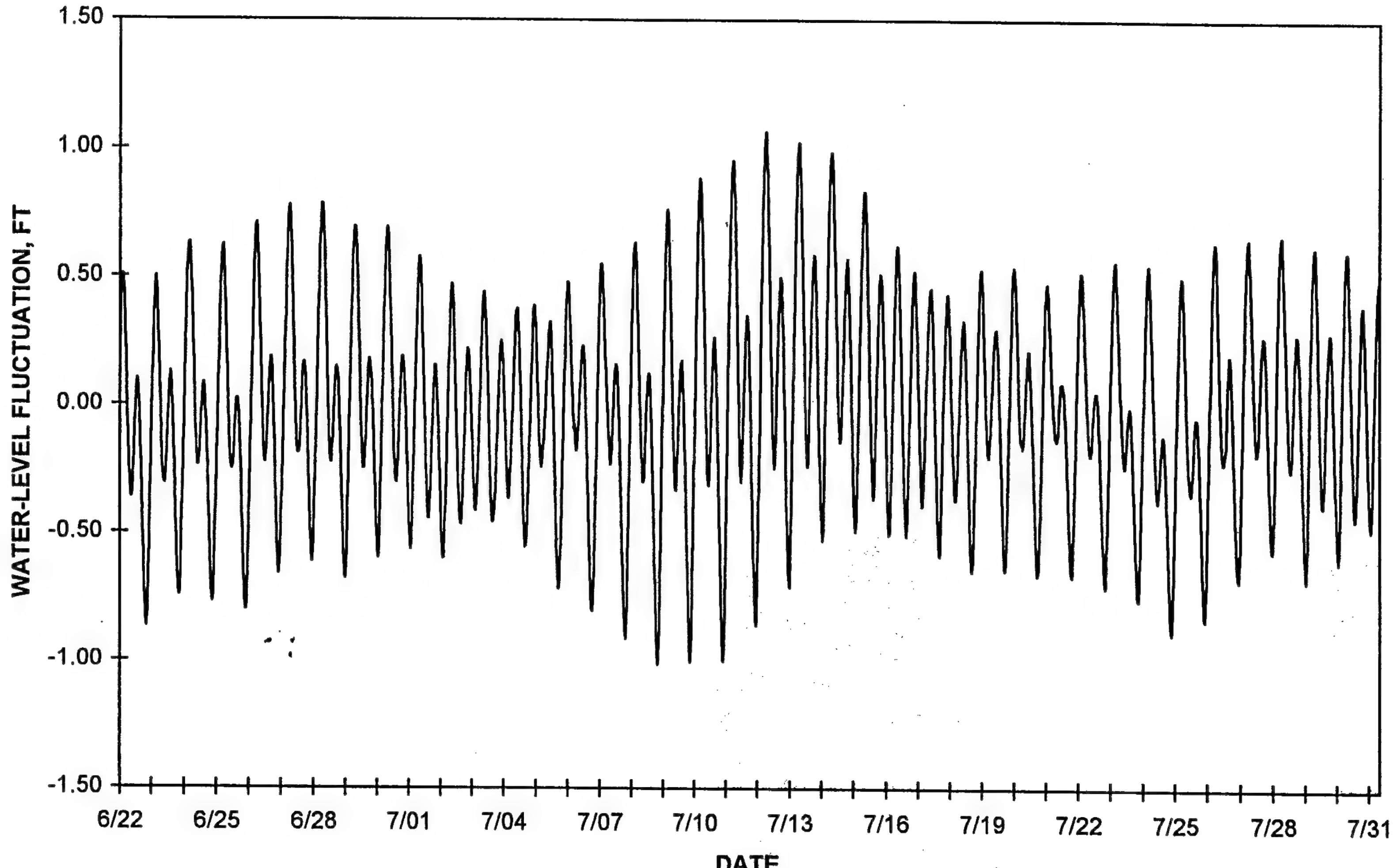


NOTE: 0.00 ft = Arbitrary Datum

WATER-LEVEL FLUCTUATIONS
STATION S6.0
8/1/95 - 8/18/95



WATER-LEVEL FLUCTUATIONS
STATION S7.0
6/23/95 - 7/31/95



NOTE: 0.00 ft = Arbitrary Datum

WATER-LEVEL FLUCTUATIONS
STATION S8.0
6/22/95 - 7/31/95

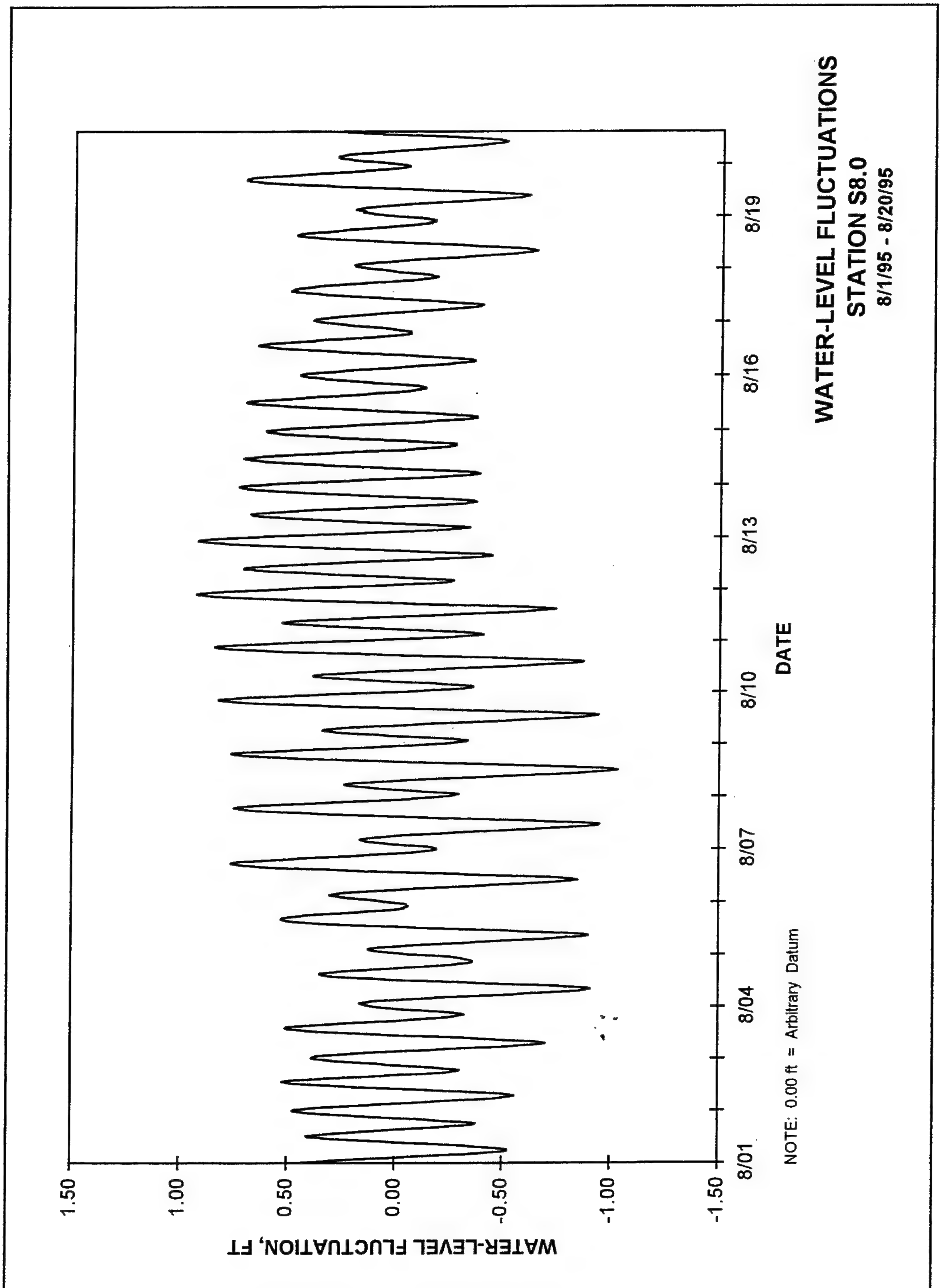
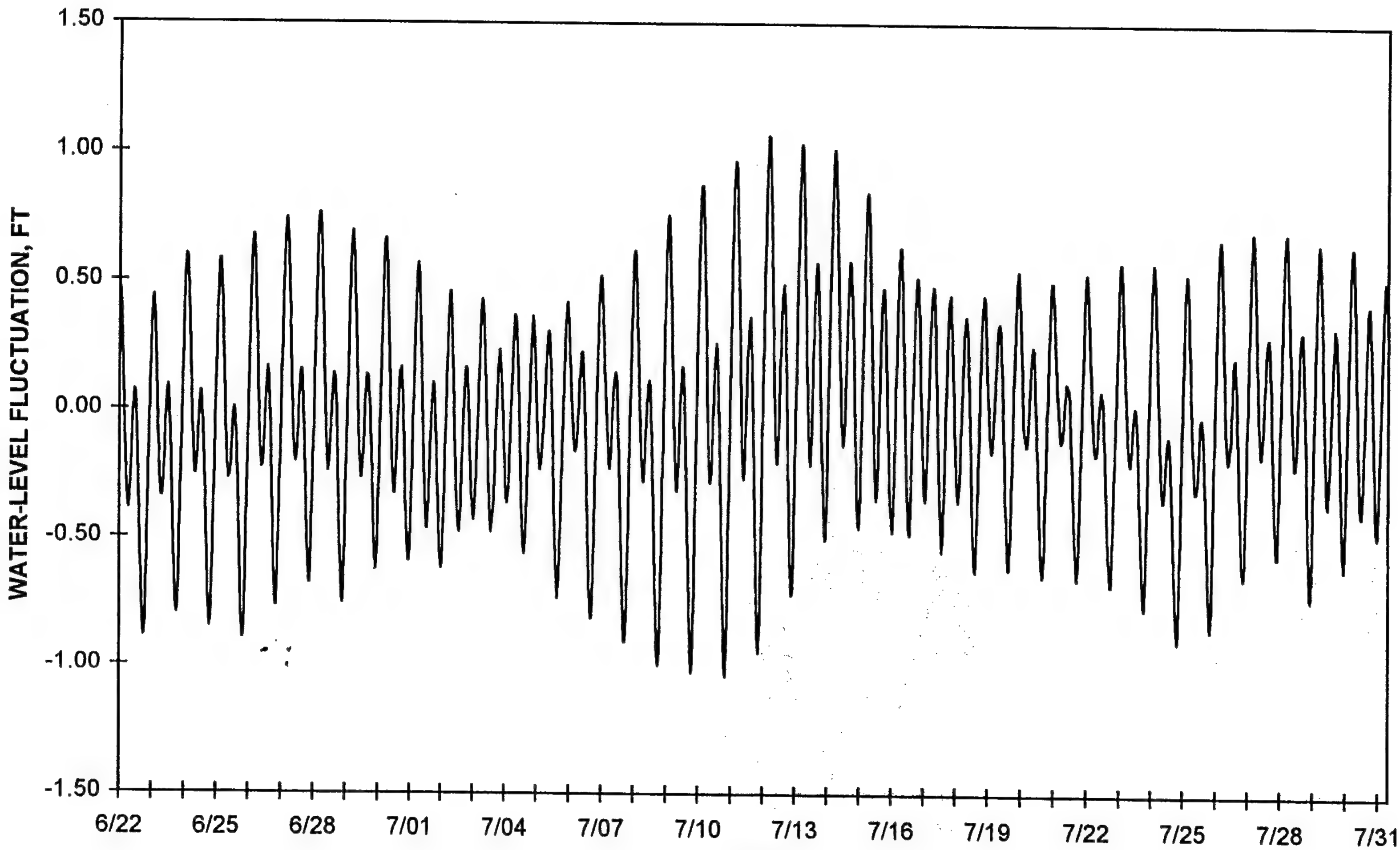
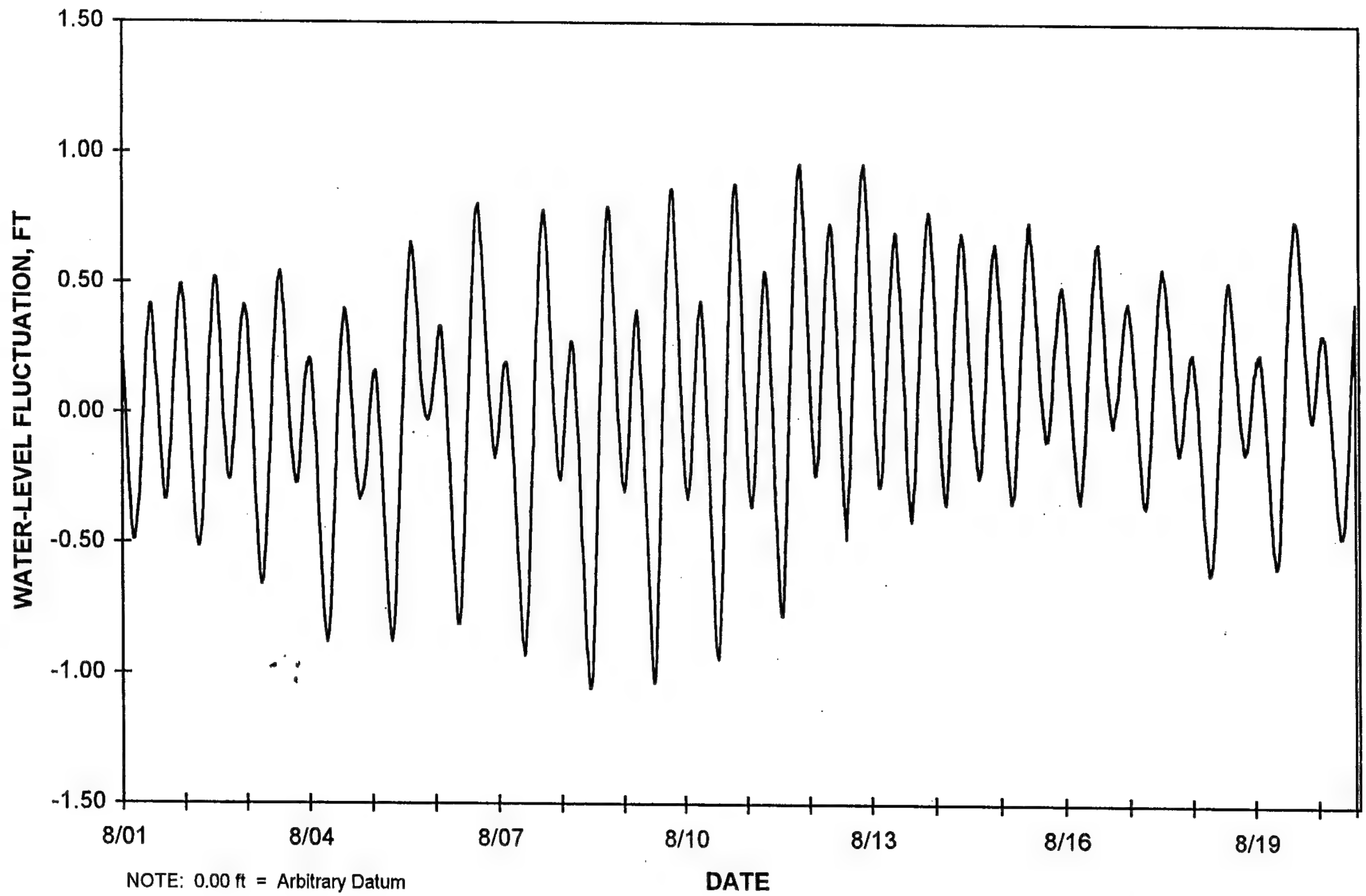

WATER-LEVEL FLUCTUATIONS
STATION S8.0
8/1/95 - 8/20/95
WATER-LEVEL FLUCTUATION, FT
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
DATE
8/01
8/04
8/07
8/10
8/13
8/16
8/19
NOTE: 0.00 ft = Arbitrary Datum

Plate 190



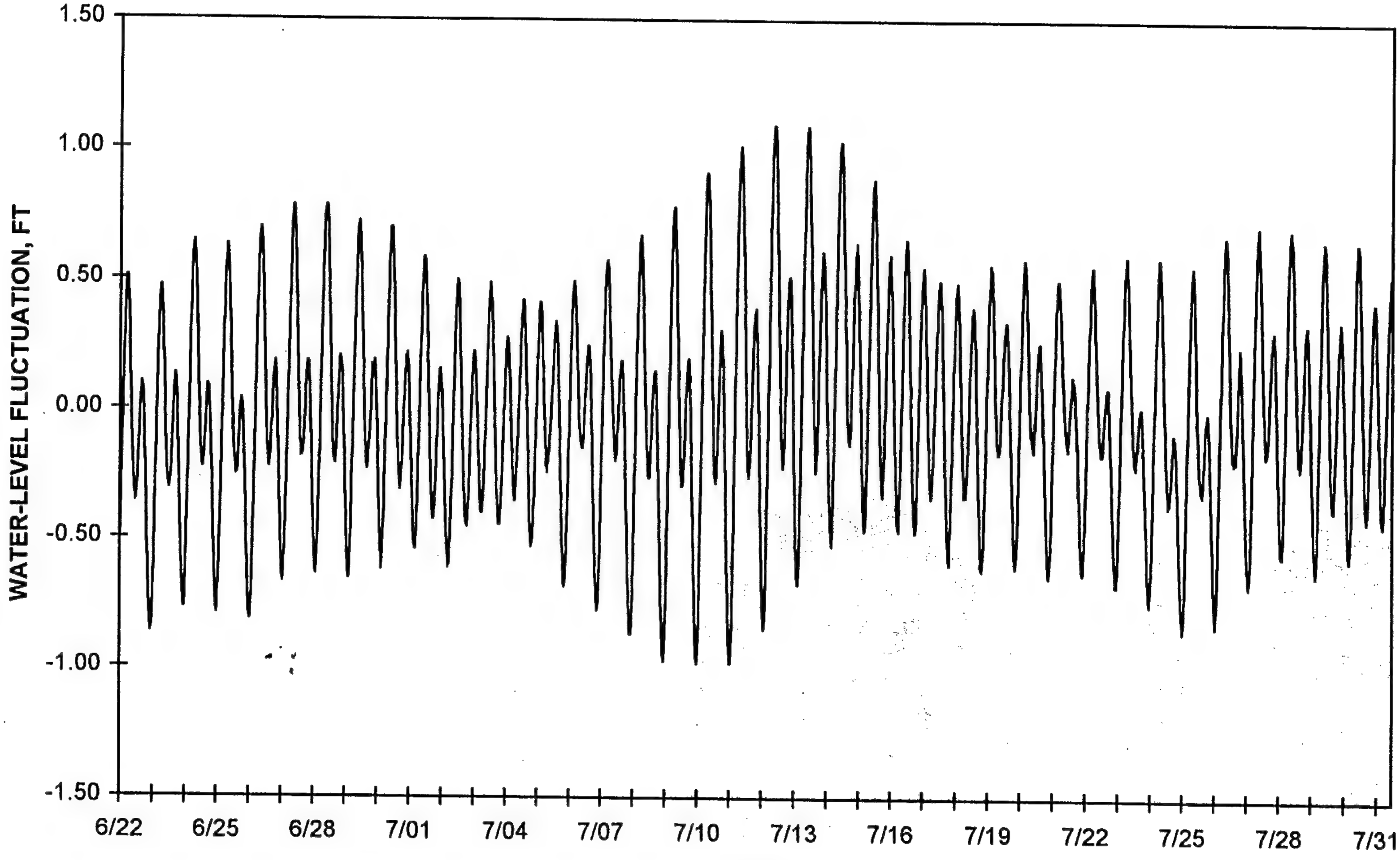
NOTE: 0.00 ft = Arbitrary Datum

WATER-LEVEL FLUCTUATIONS
STATION S9.0
6/22/95 - 7/31/95



NOTE: 0.00 ft = Arbitrary Datum

WATER-LEVEL FLUCTUATIONS
STATION S9.0
8/1/95 - 8/20/95



NOTE: 0.00 ft = Arbitrary Datum

WATER-LEVEL FLUCTUATIONS
STATION S10.0
6/22/95 - 7/31/95

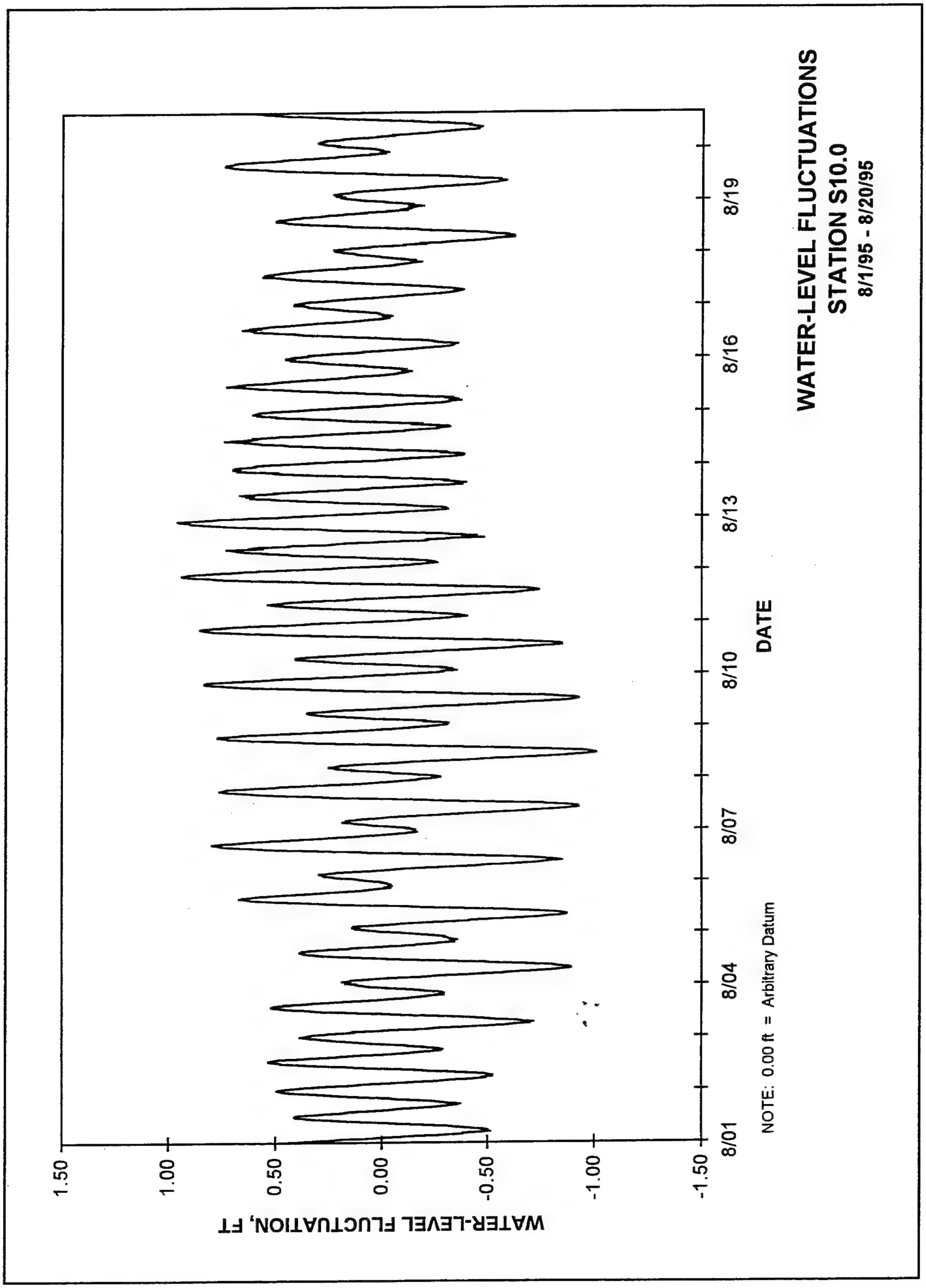
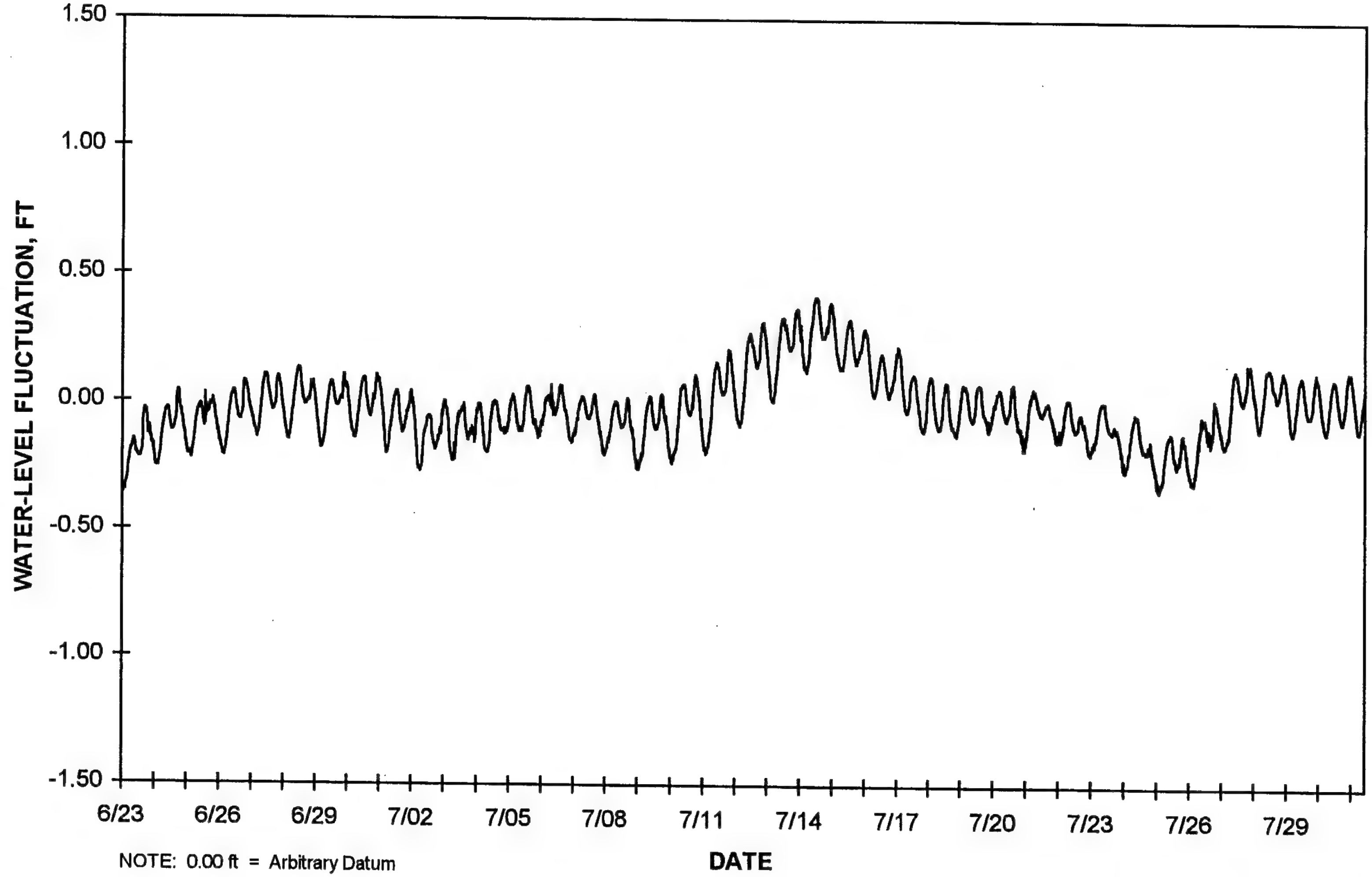
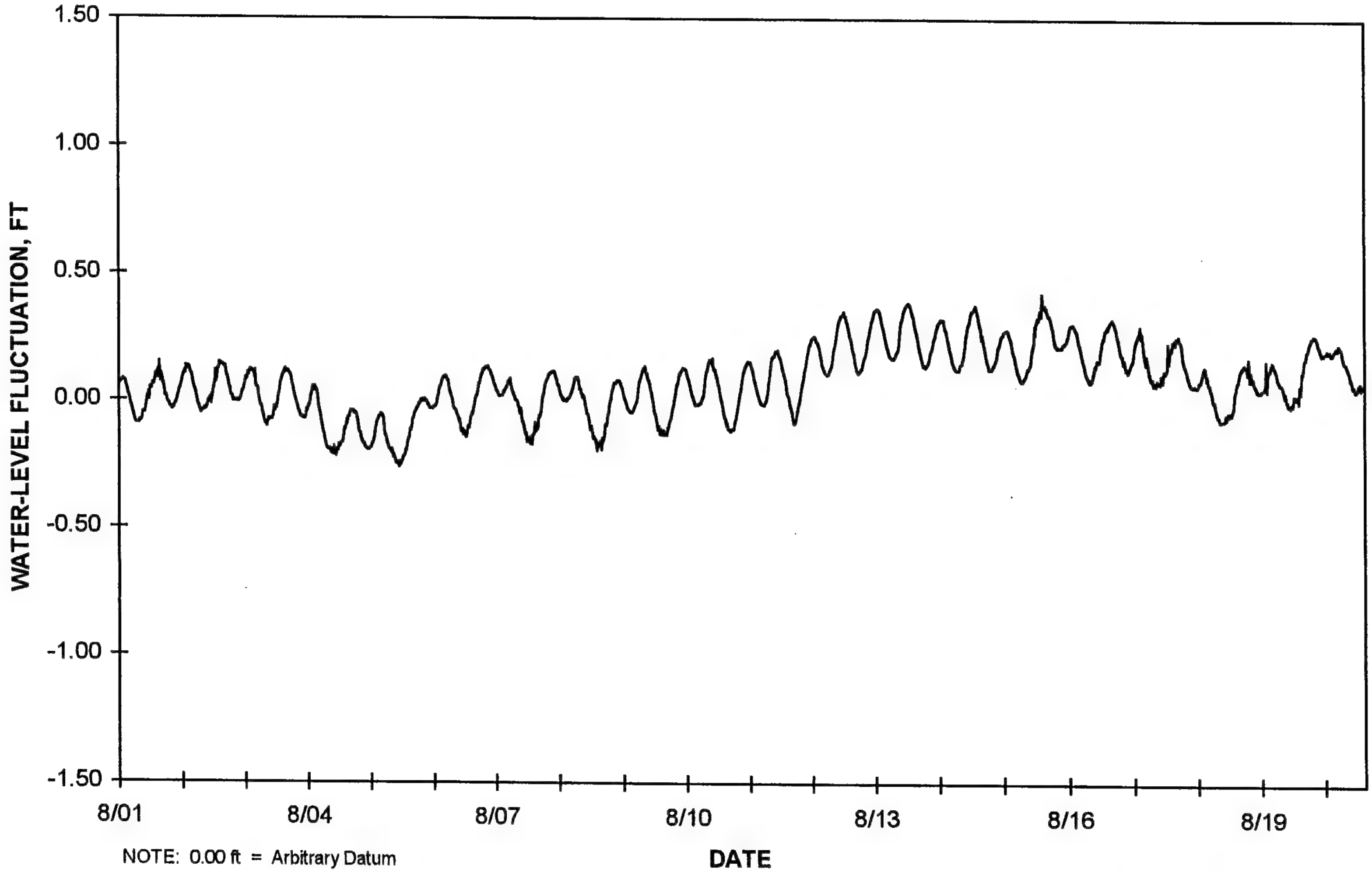

WATER-LEVEL FLUCTUATIONS
STATION S10.0
8/1/95 - 8/20/95
WATER-LEVEL FLUCTUATION, FT
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
DATE
8/01
8/04
8/07
8/10
8/13
8/16
8/19
NOTE: 0.00 ft = Arbitrary Datum

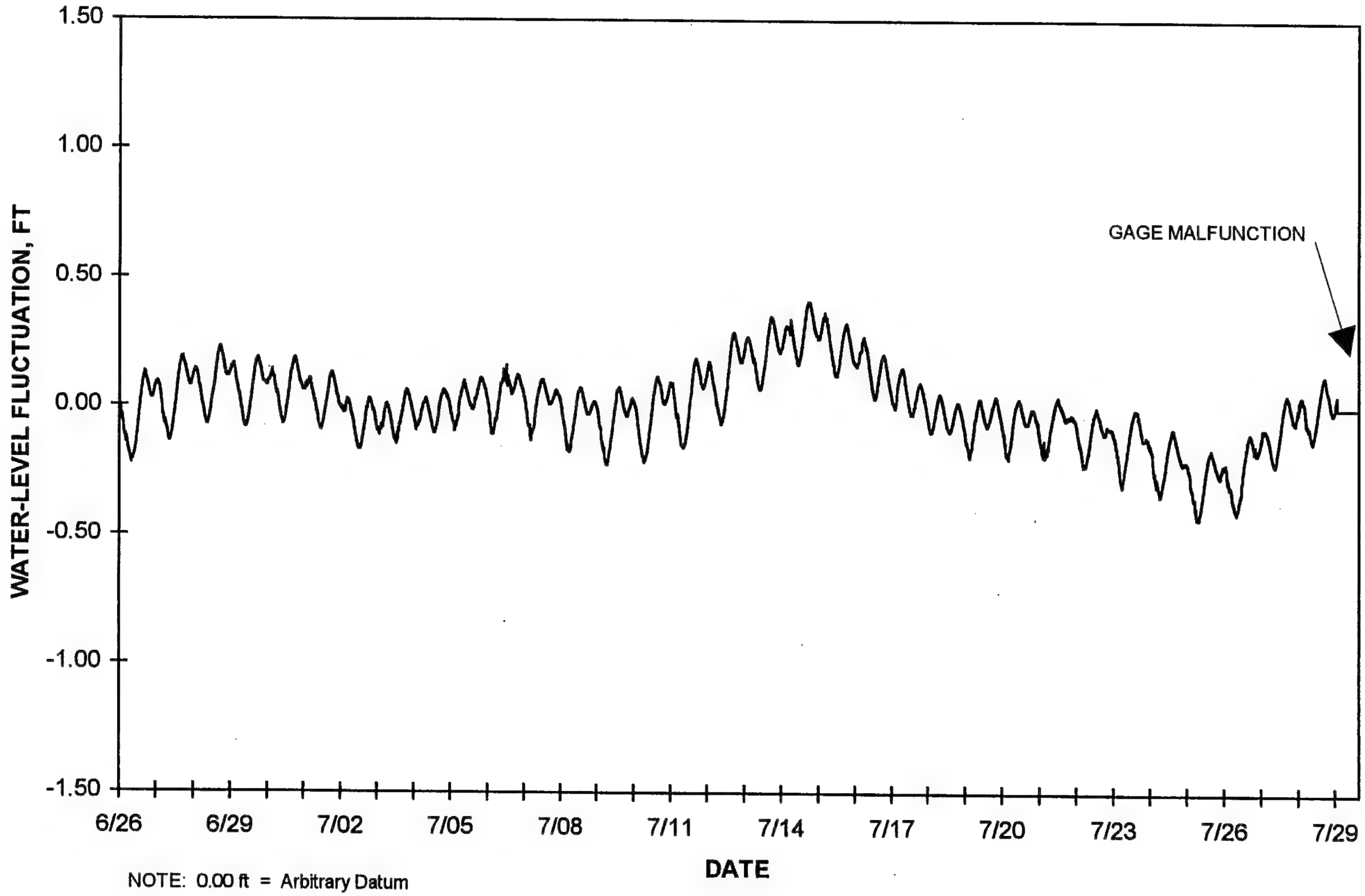
Plate 194



WATER-LEVEL FLUCTUATIONS
STATION S11.0
6/23/95 - 7/31/95

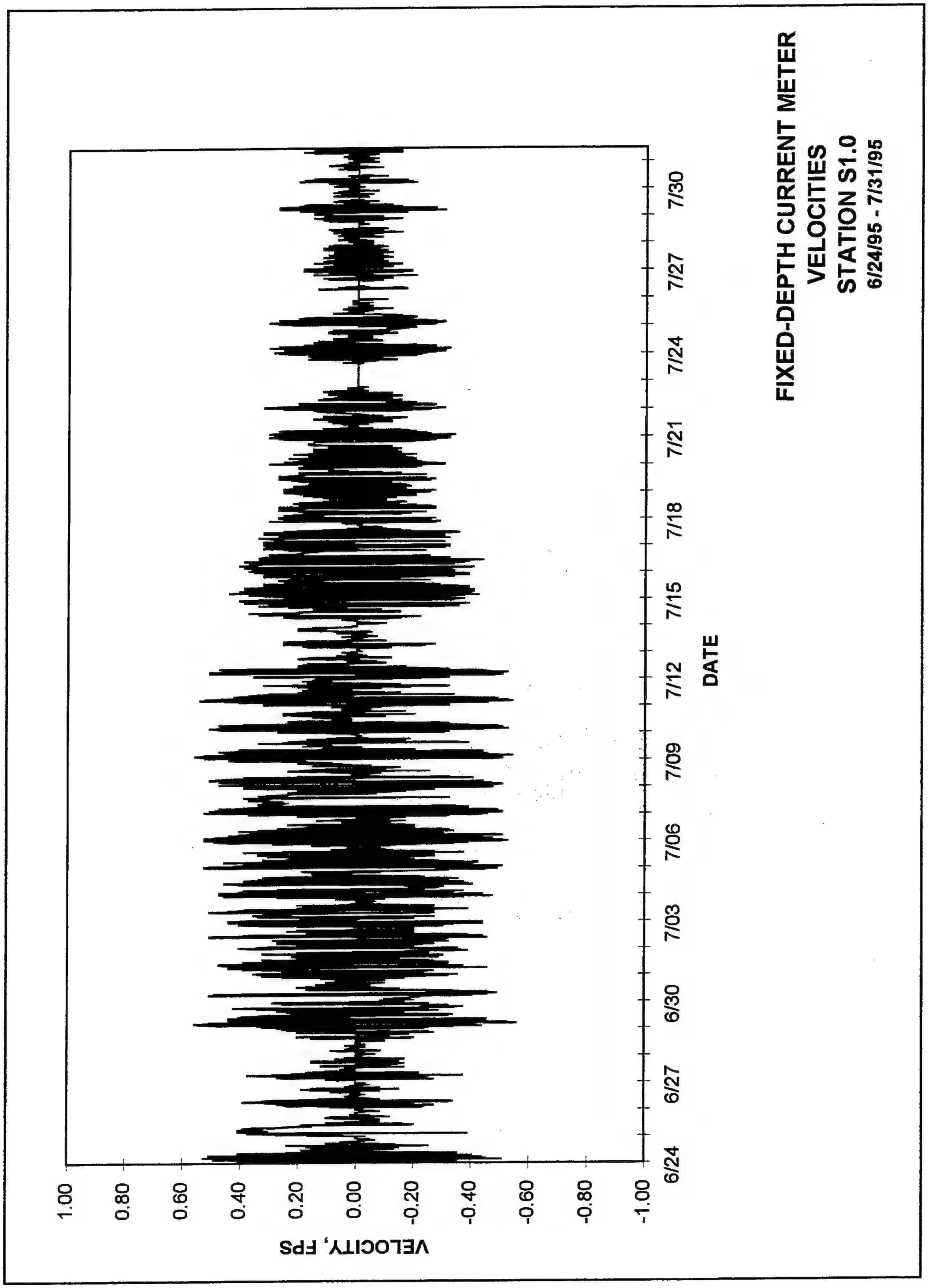


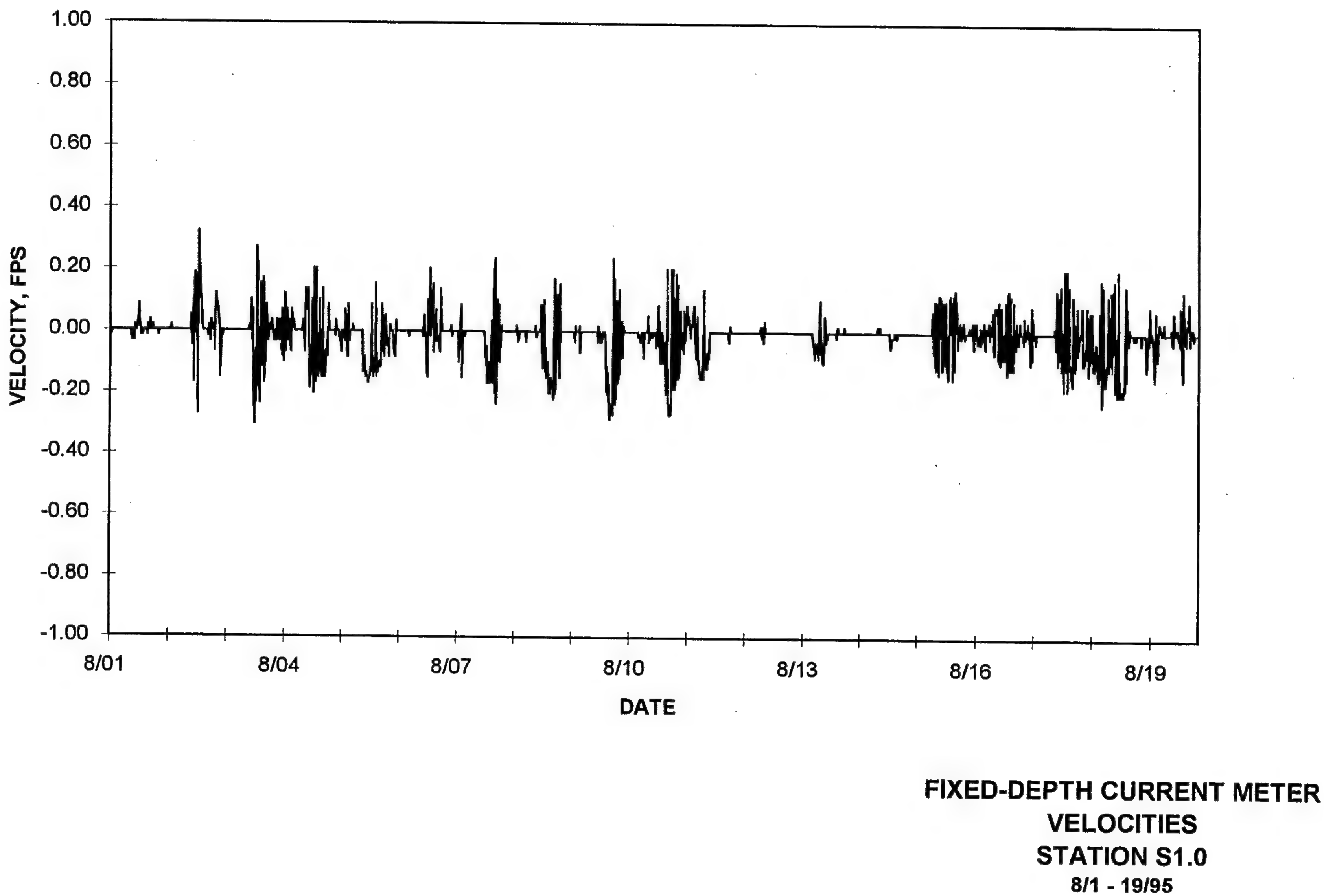
WATER-LEVEL FLUCTUATIONS
STATION S11.0
8/1/95 - 8/20/95



NOTE: 0.00 ft = Arbitrary Datum

WATER-LEVEL FLUCTUATIONS
STATION S12.0
6/26/95 - 7/29/95


FIXED-DEPTH CURRENT METER
VELOCITIES
STATION S1.0
6/24/95 - 7/31/95
VELOCITY, FPS
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
DATE
6/24
6/27
6/30
7/03
7/06
7/09
7/12
7/15
7/18
7/21
7/24
7/27
7/30


1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
VELOCITY, FPS
8/01
8/04
8/07
8/10
8/13
8/16
8/19
DATE
FIXED-DEPTH CURRENT METER
VELOCITIES
STATION S1.0
8/1 - 19/95

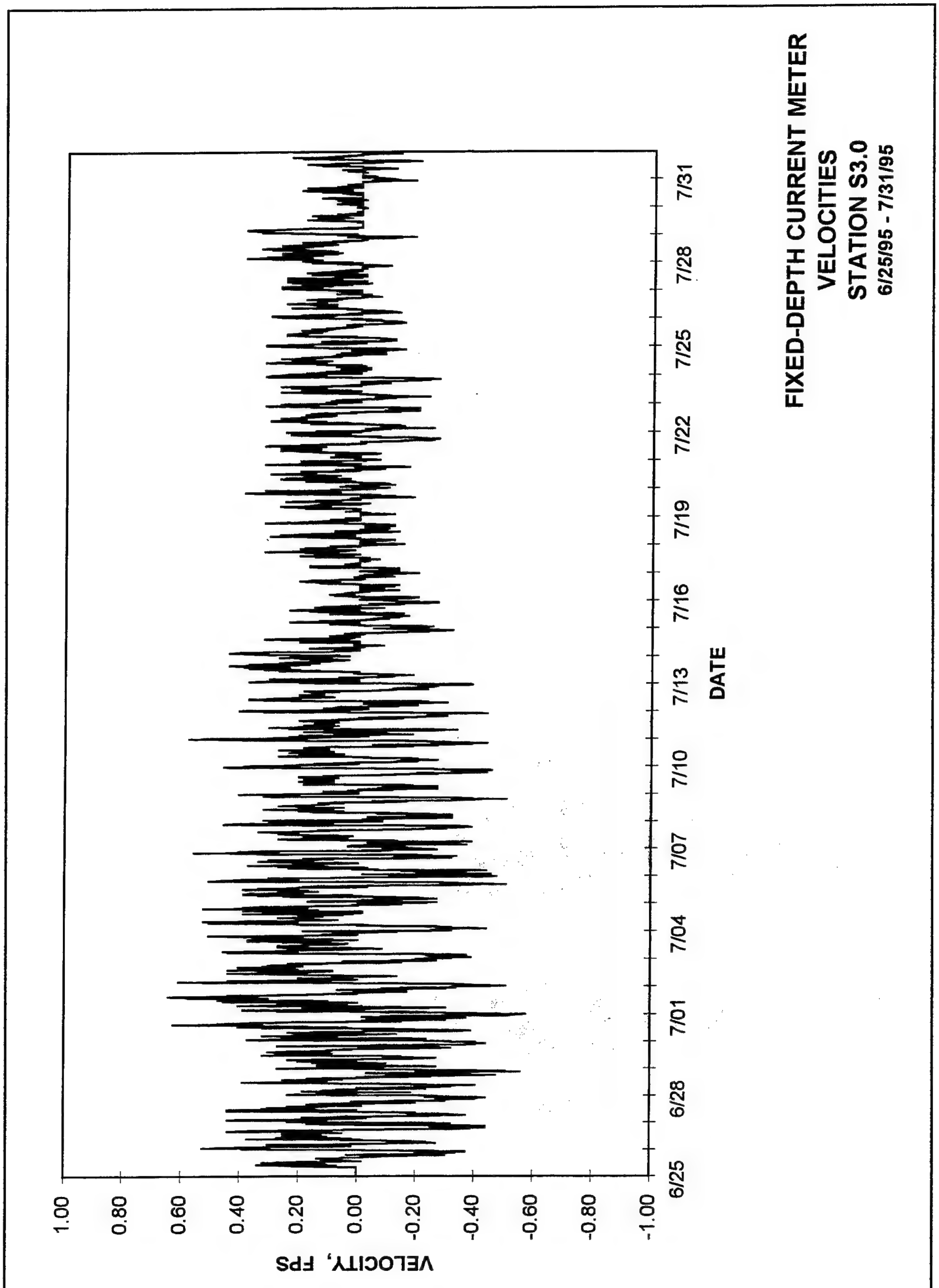
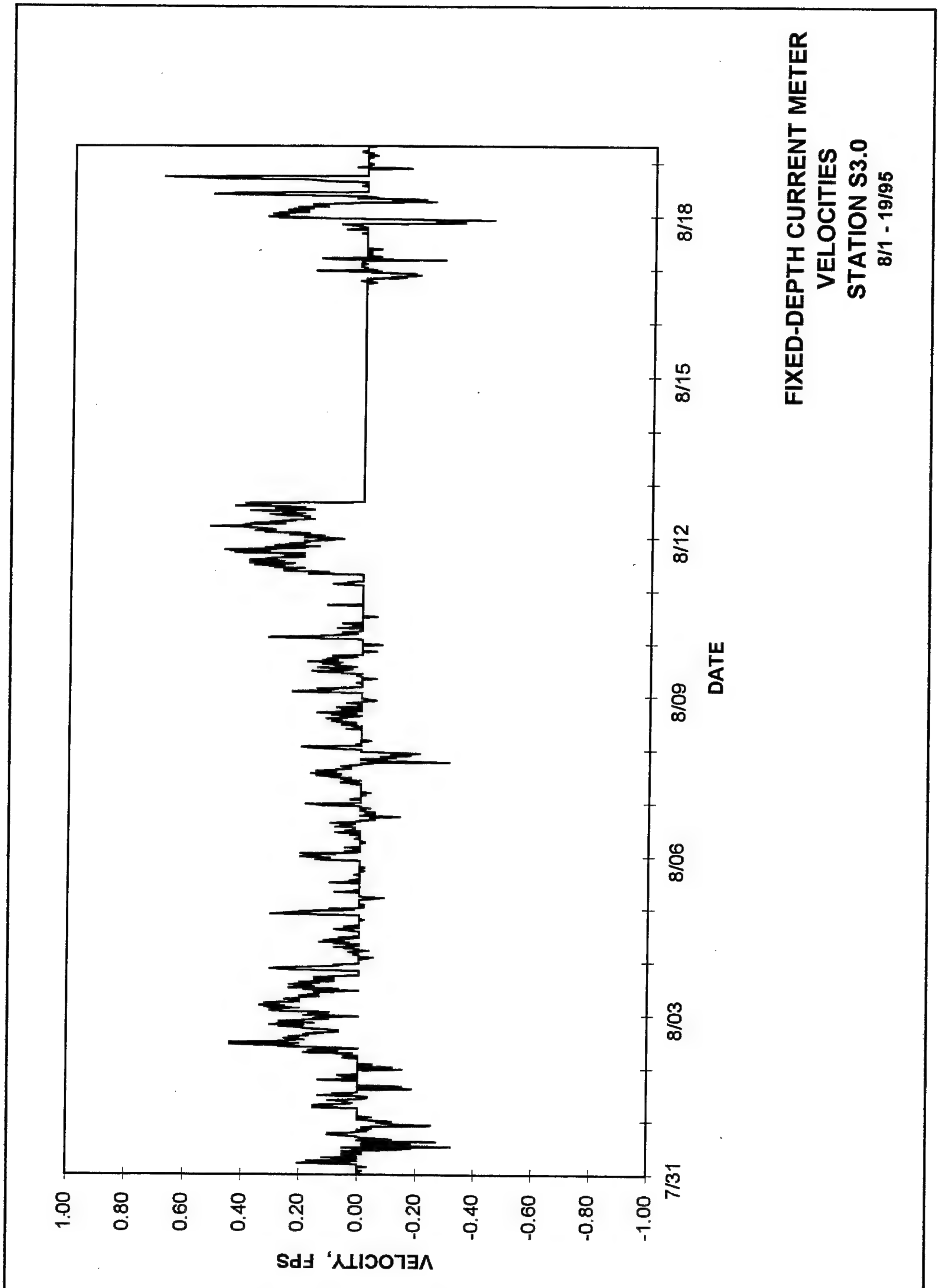
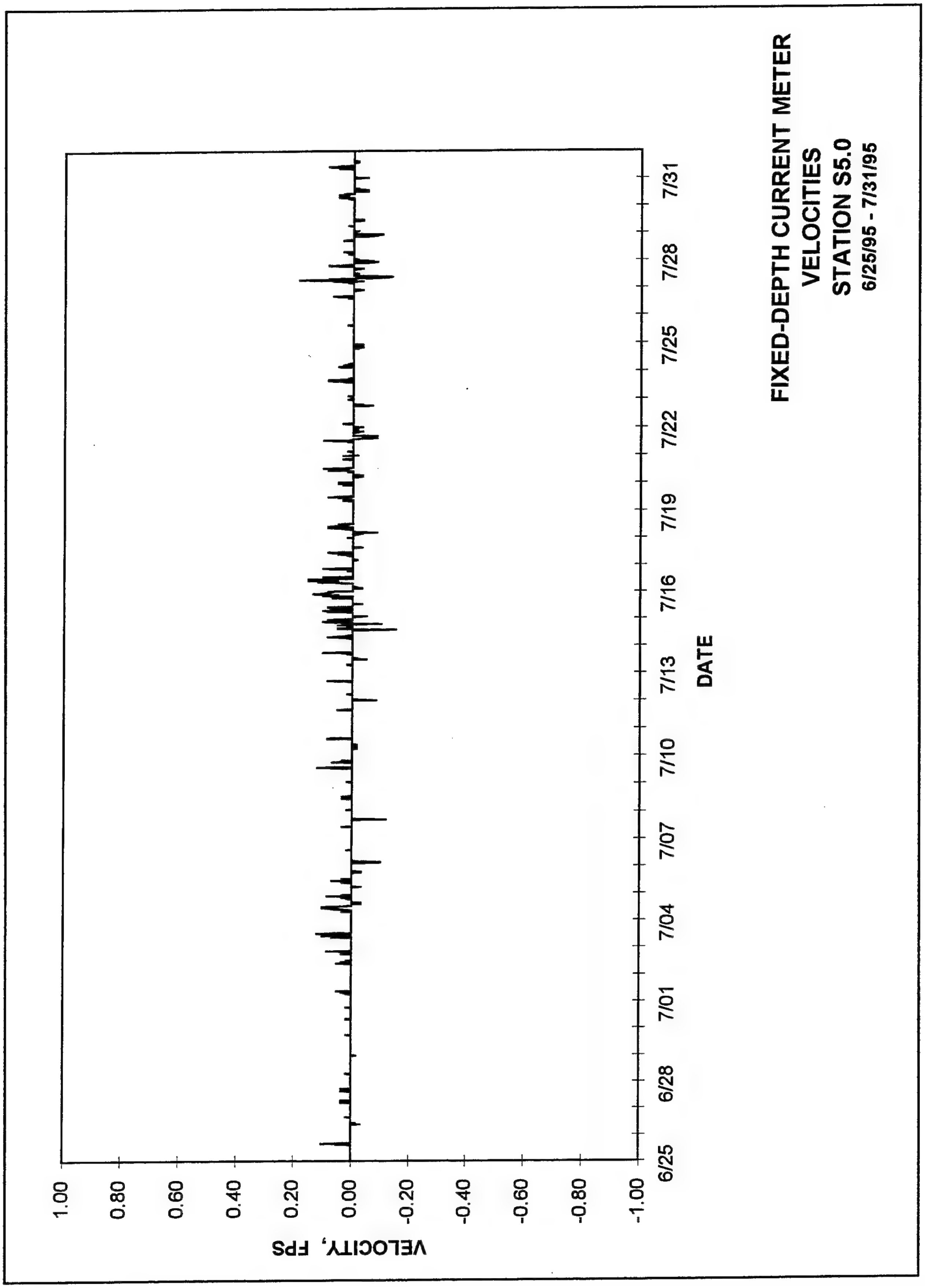

FIXED-DEPTH CURRENT METER
VELOCITIES
STATION S3.0
6/25/95 - 7/31/95
VELOCITY, FPS
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
DATE
6/25
6/28
7/01
7/04
7/07
7/10
7/13
7/16
7/19
7/22
7/25
7/28
7/31

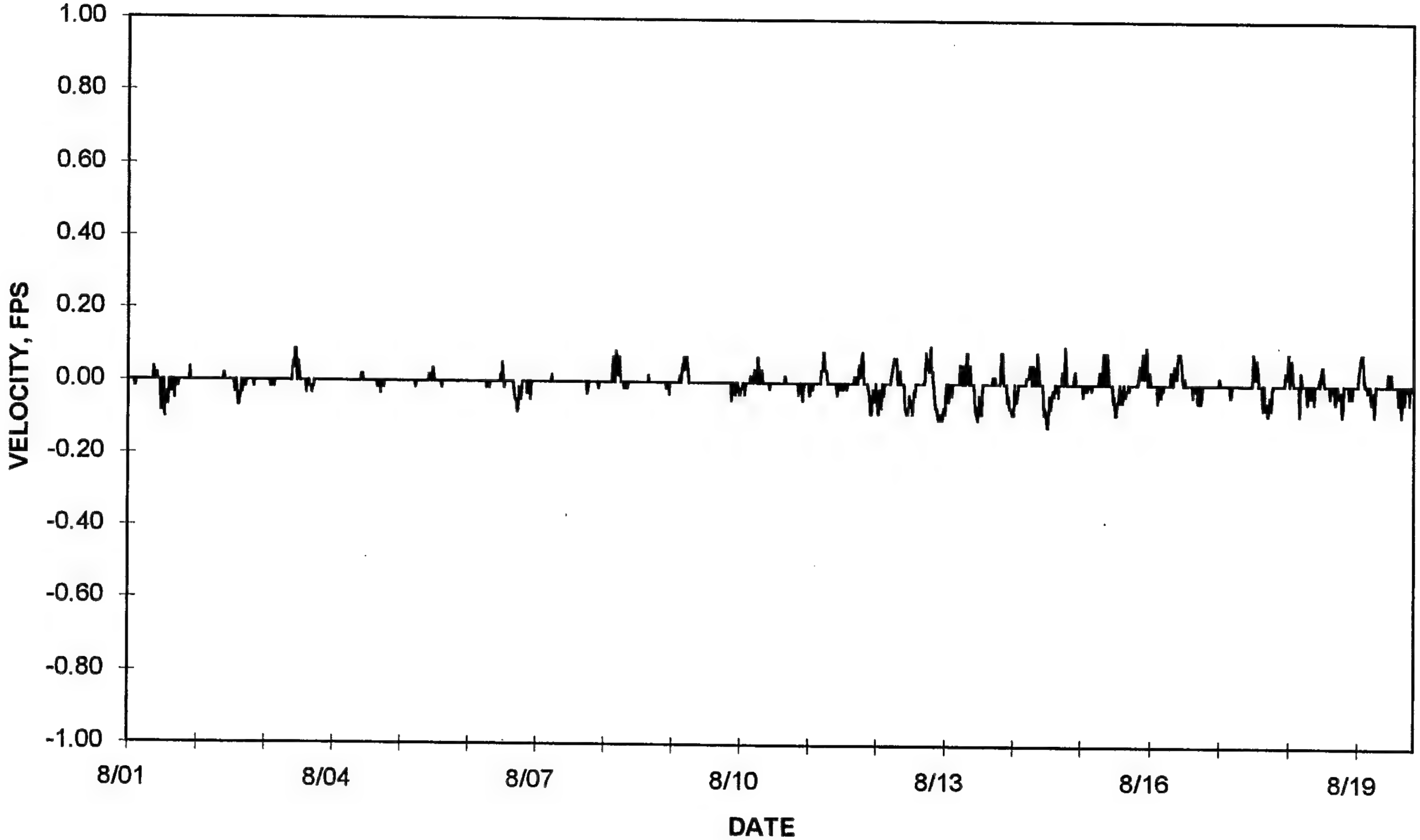
Plate 200


FIXED-DEPTH CURRENT METER
VELOCITIES
STATION S3.0
8/1 - 19/95
VELOCITY, FPS
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
7/31
8/03
8/06
8/09
8/12
8/15
8/18
DATE



FIXED-DEPTH CURRENT METER VELOCITIES
STATION S5.0
6/25/95 - 7/31/95

Plate 202



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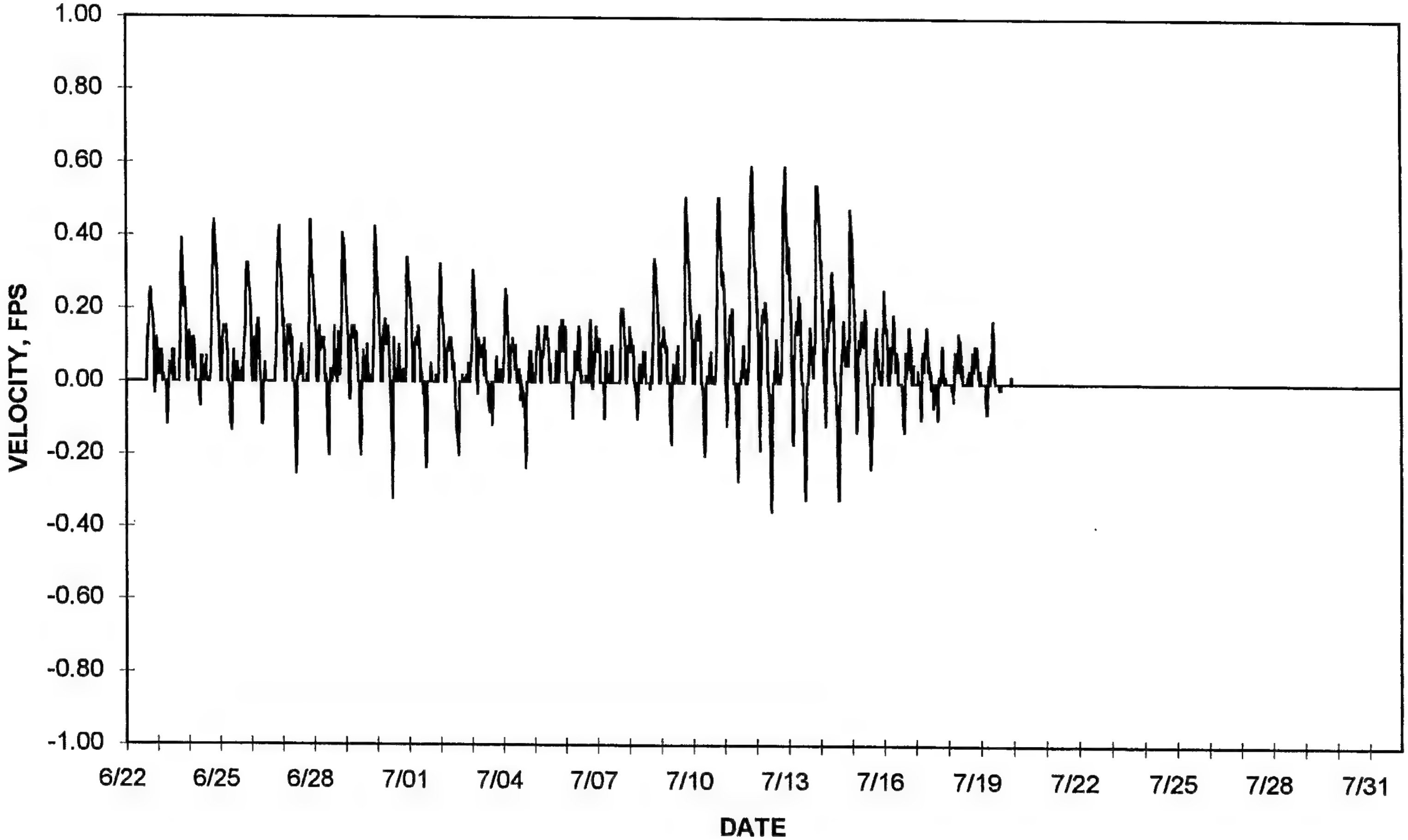
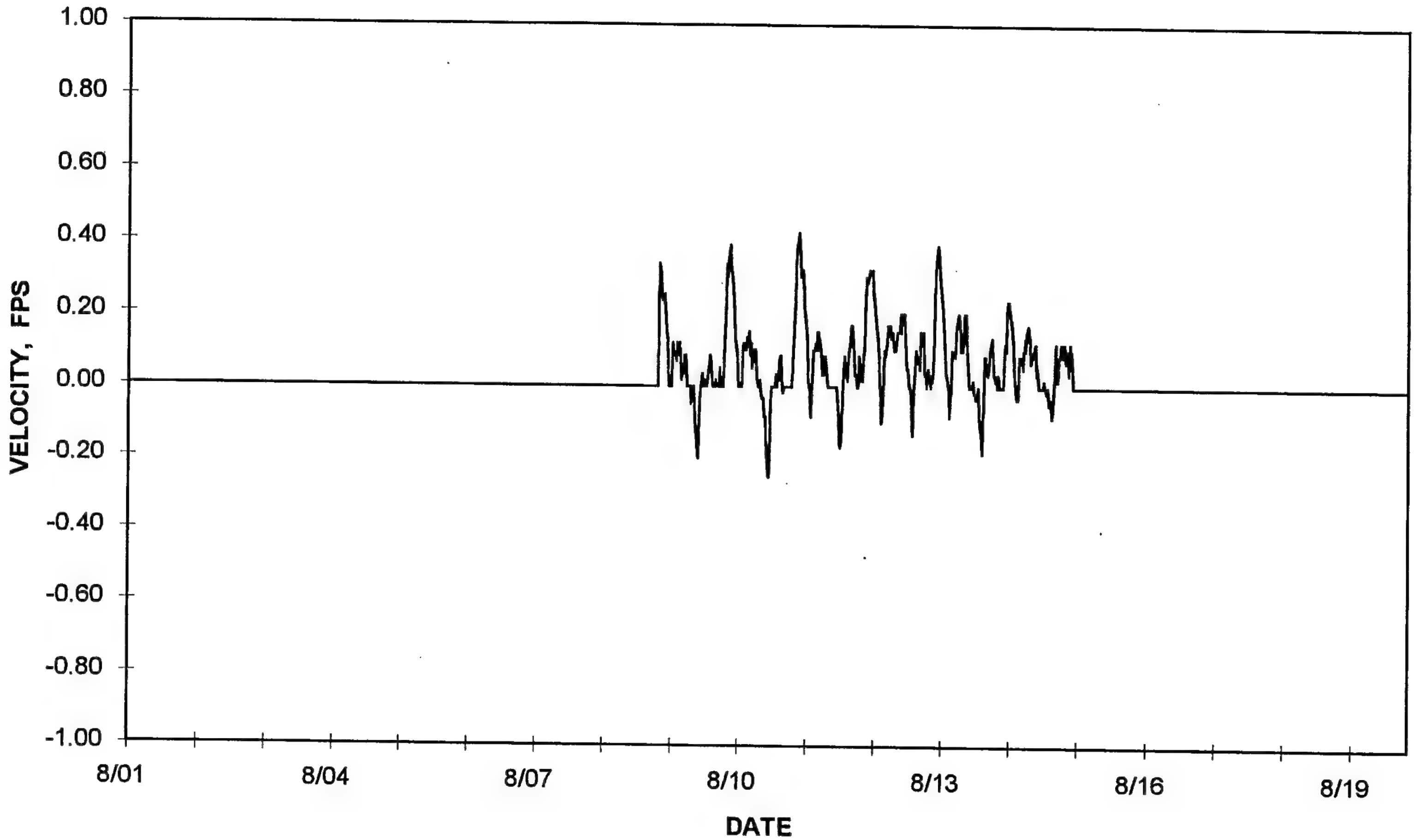
VELOCITIES
STATION S5.0
8/1 - 19/95



FIXED-DEPTH CURRENT METER VELOCITIES
STATION S8.0
6/22/95 - 7/31/95

Plate 204



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8/1 - 19/95

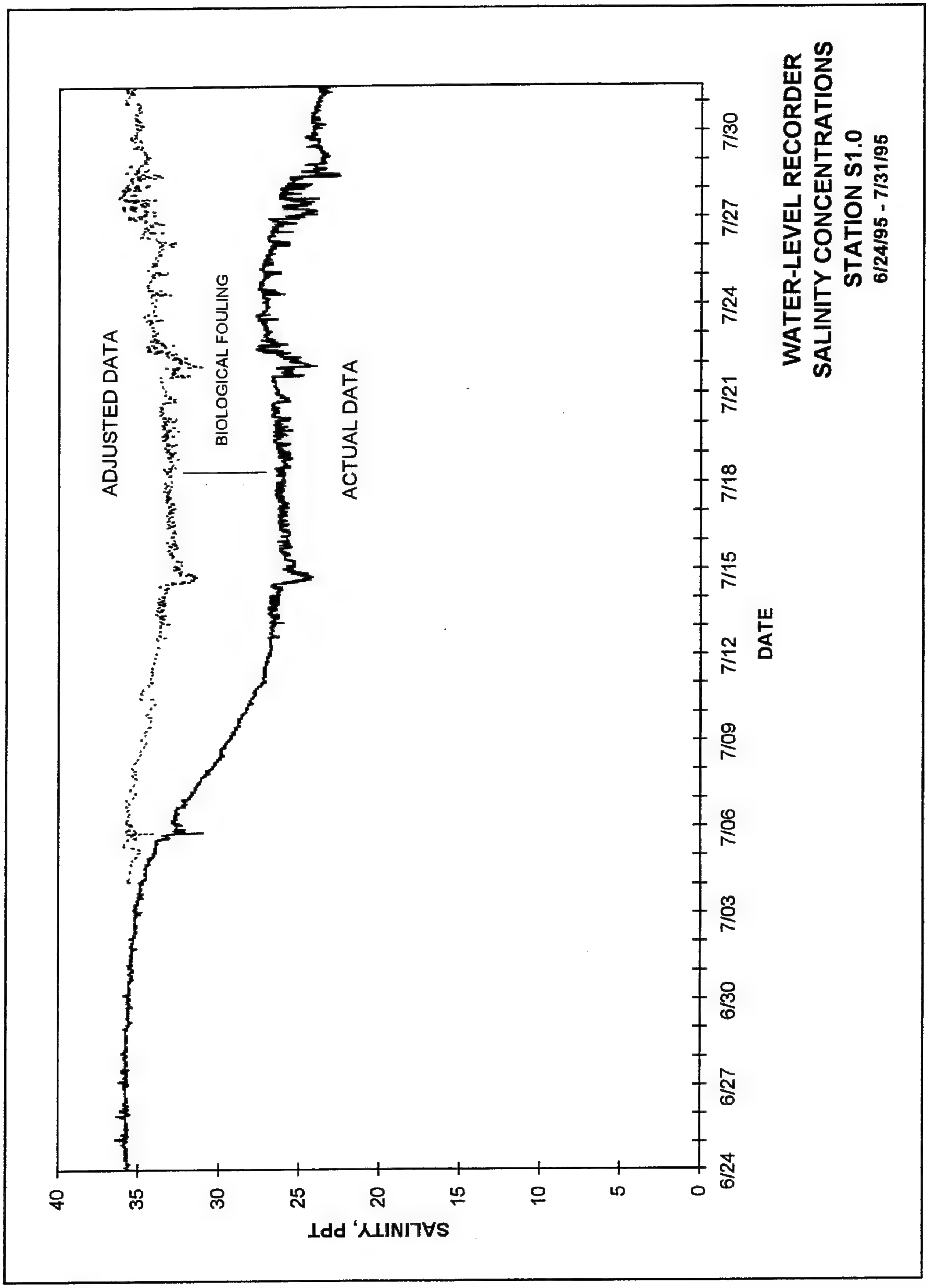
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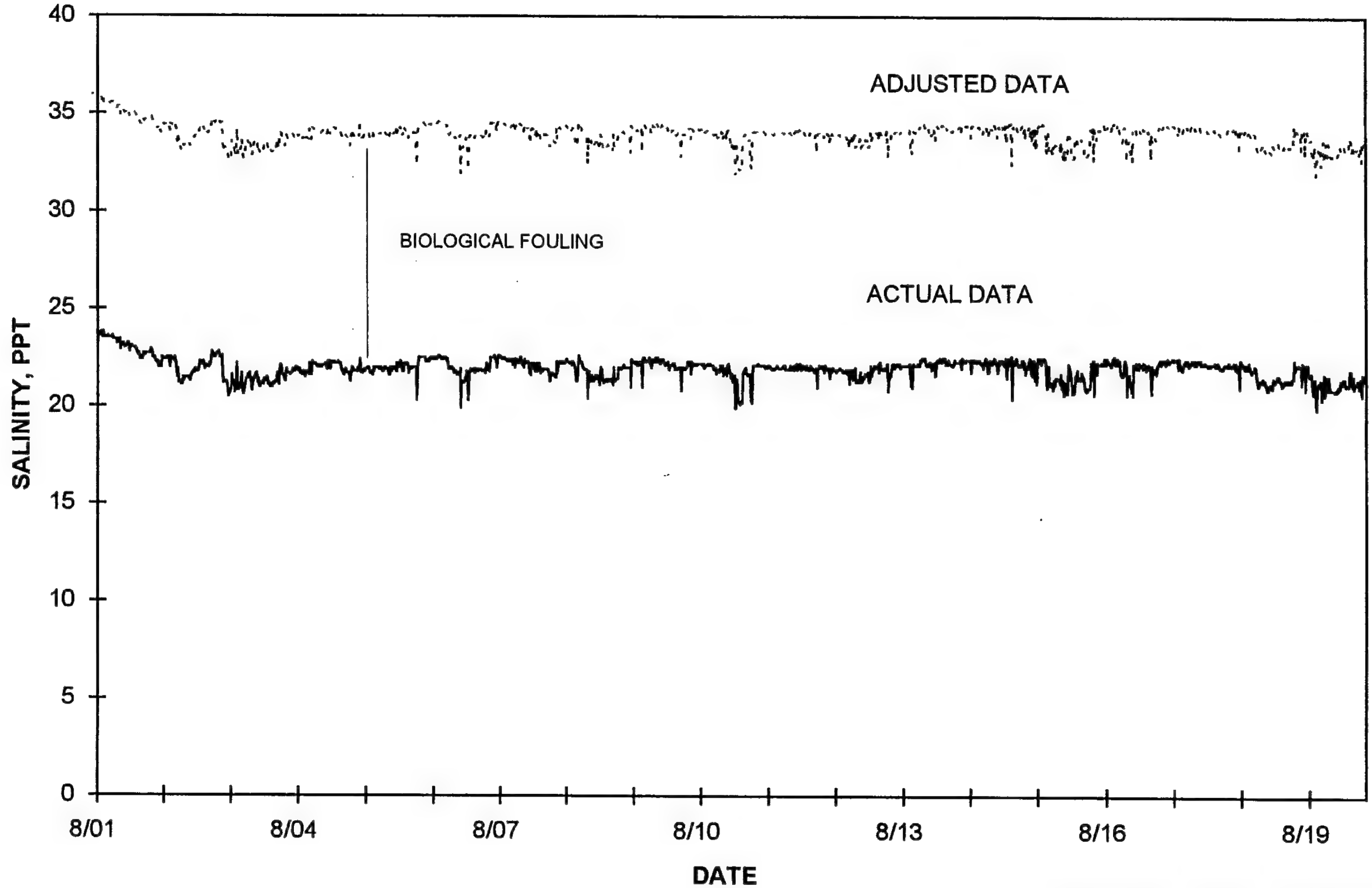
Plate 206



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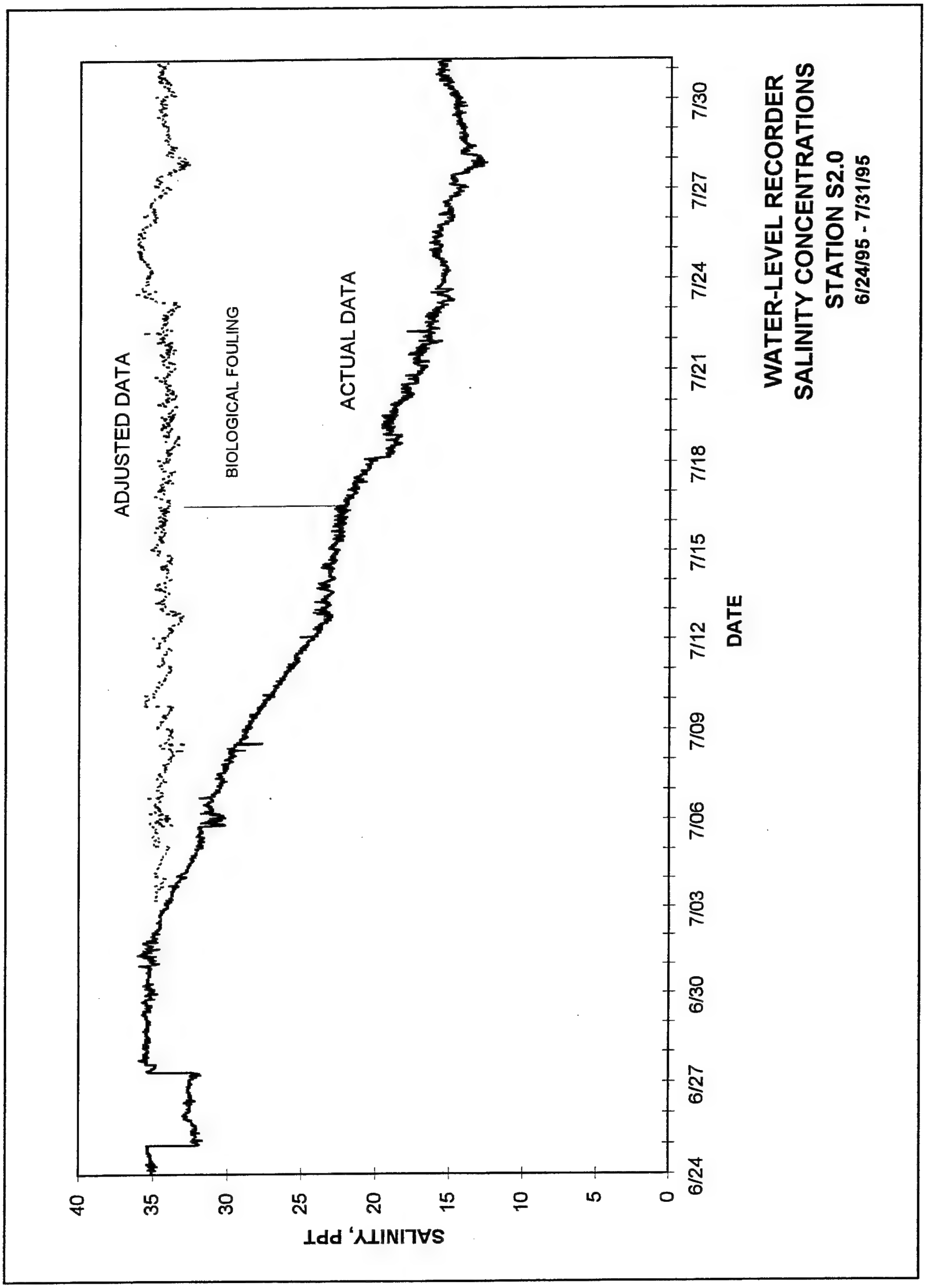
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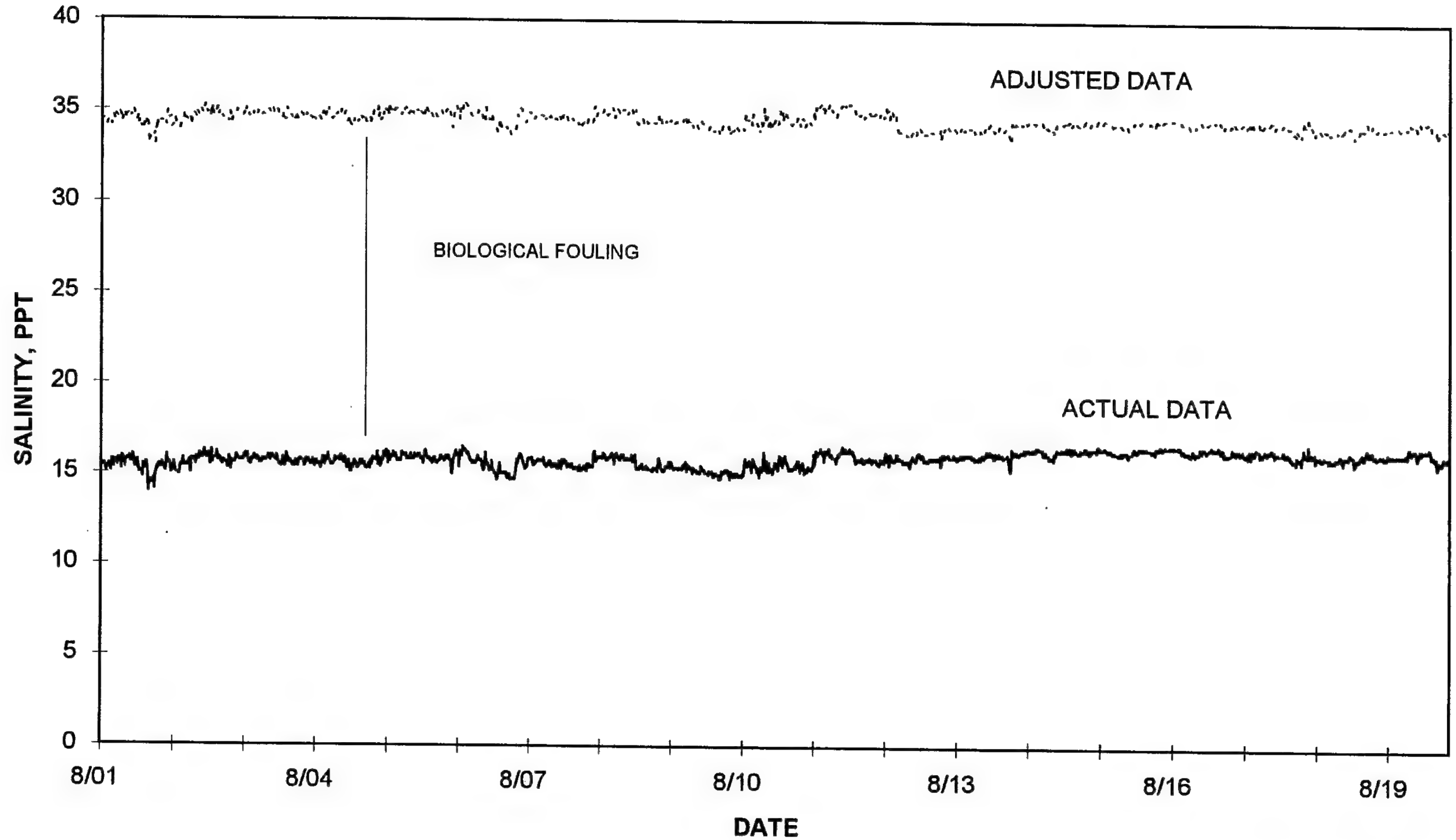
Plate 208



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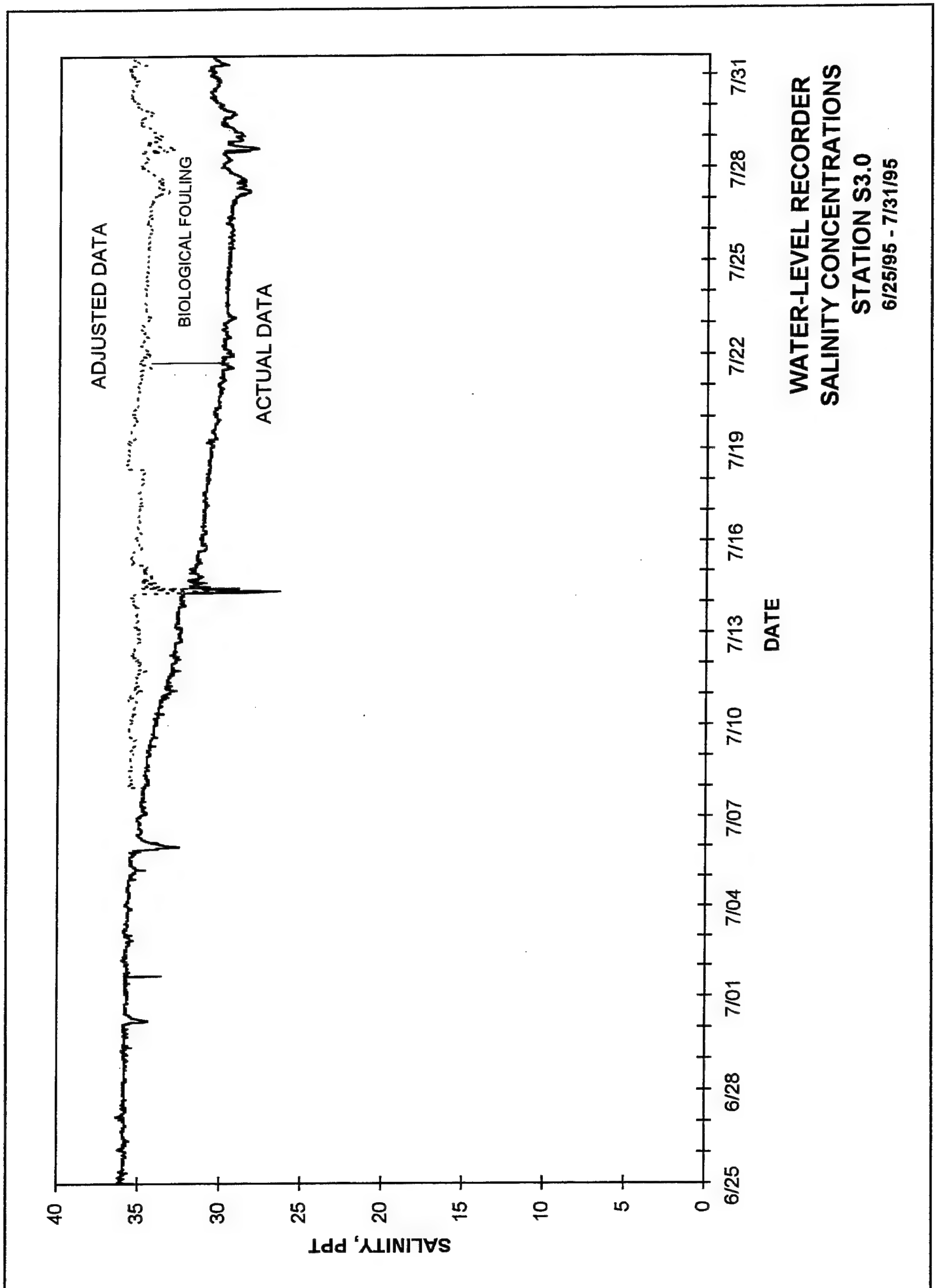
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ACTUAL DATA
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Plate 210

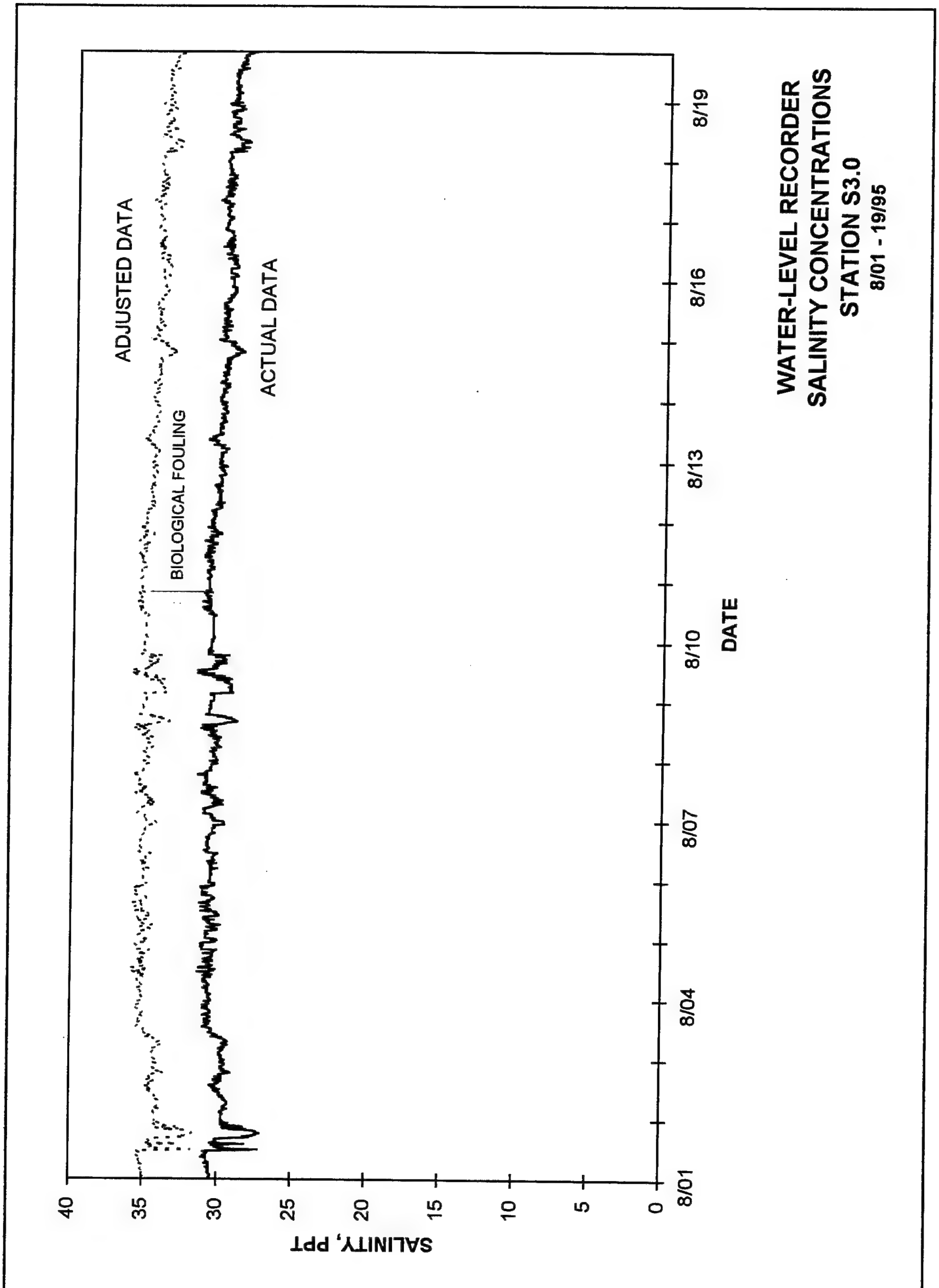
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Plate 211

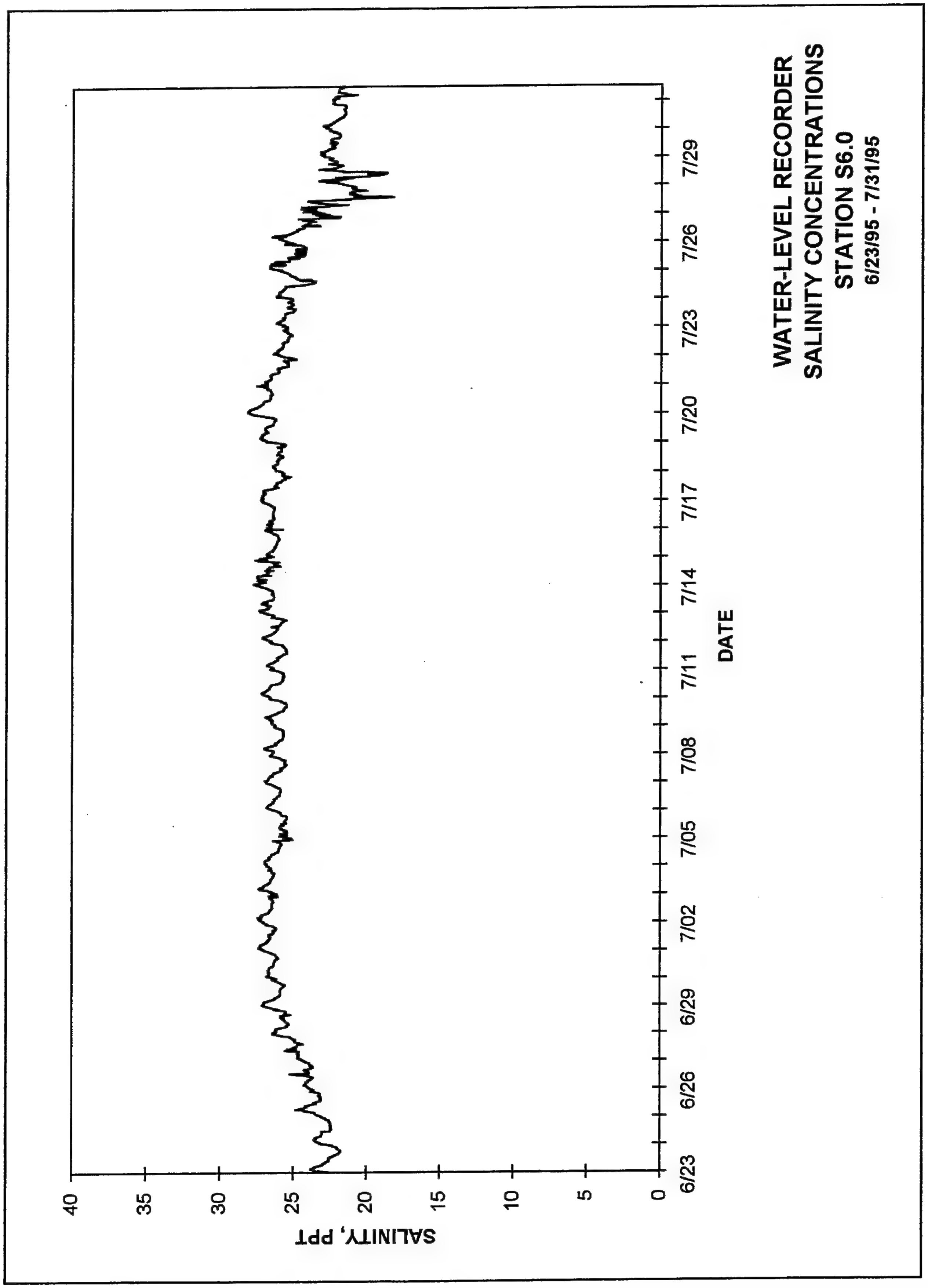
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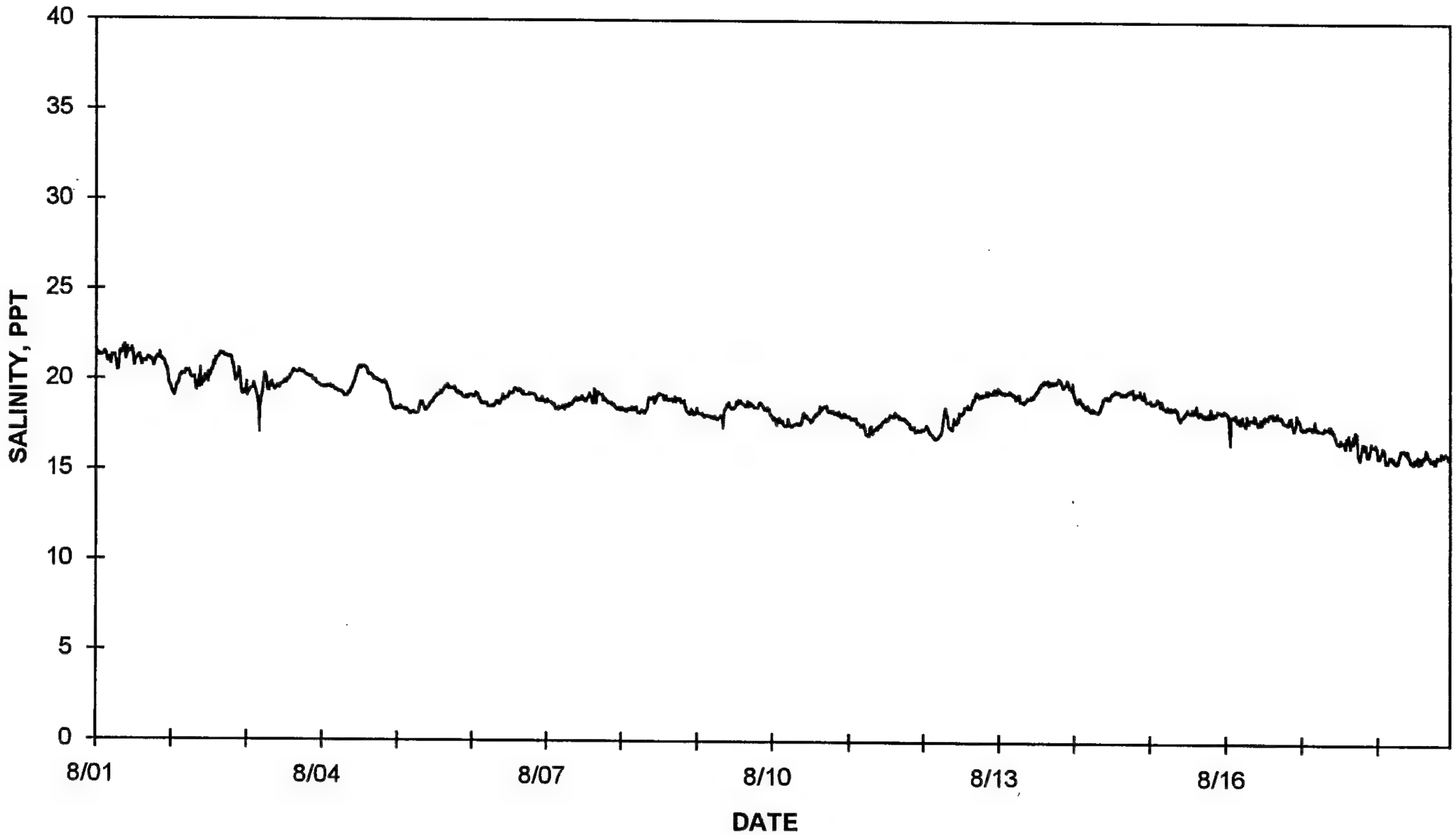
Plate 212



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SALINITY CONCENTRATIONS
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8/1/95 - 8/18/95

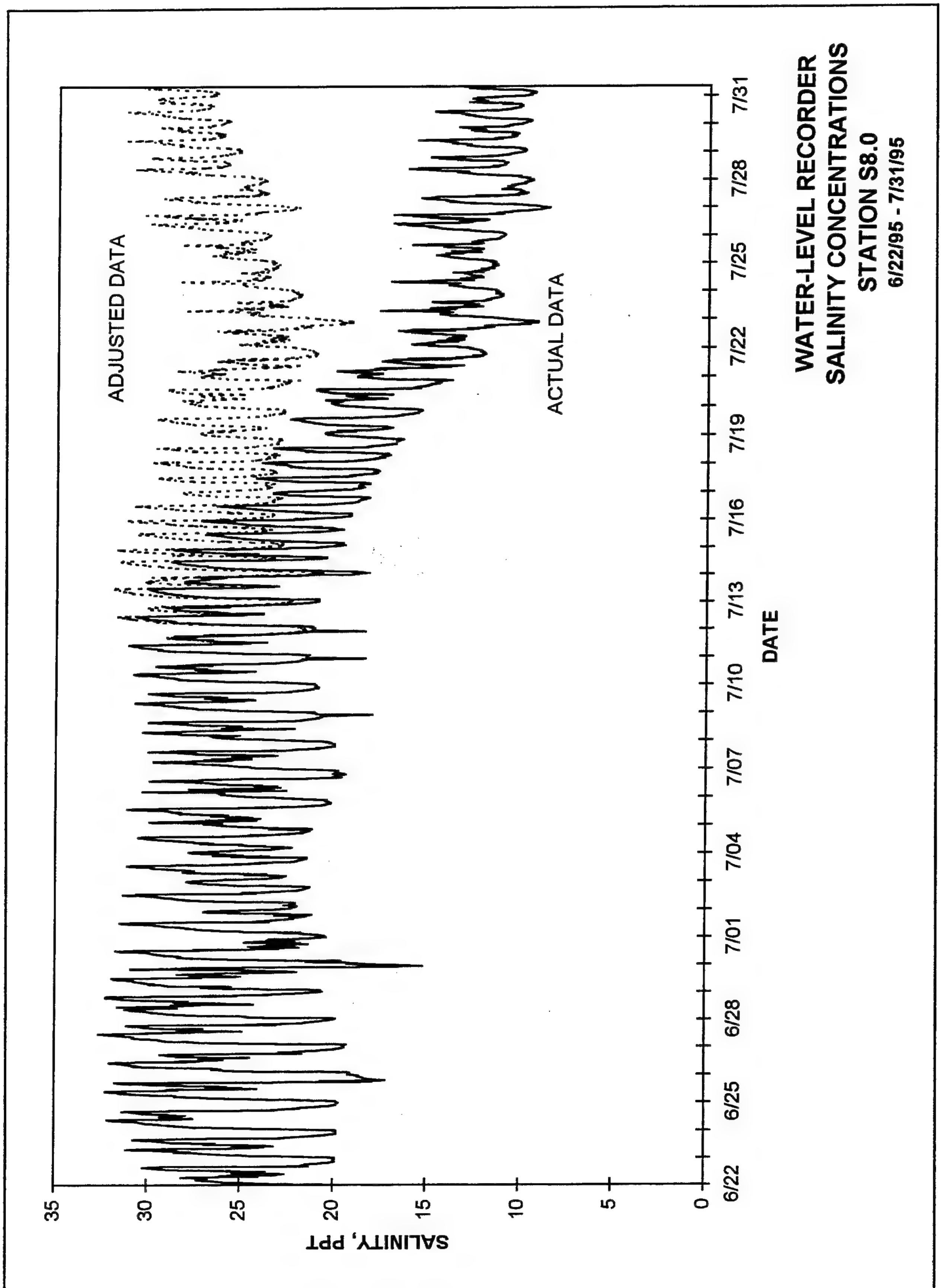

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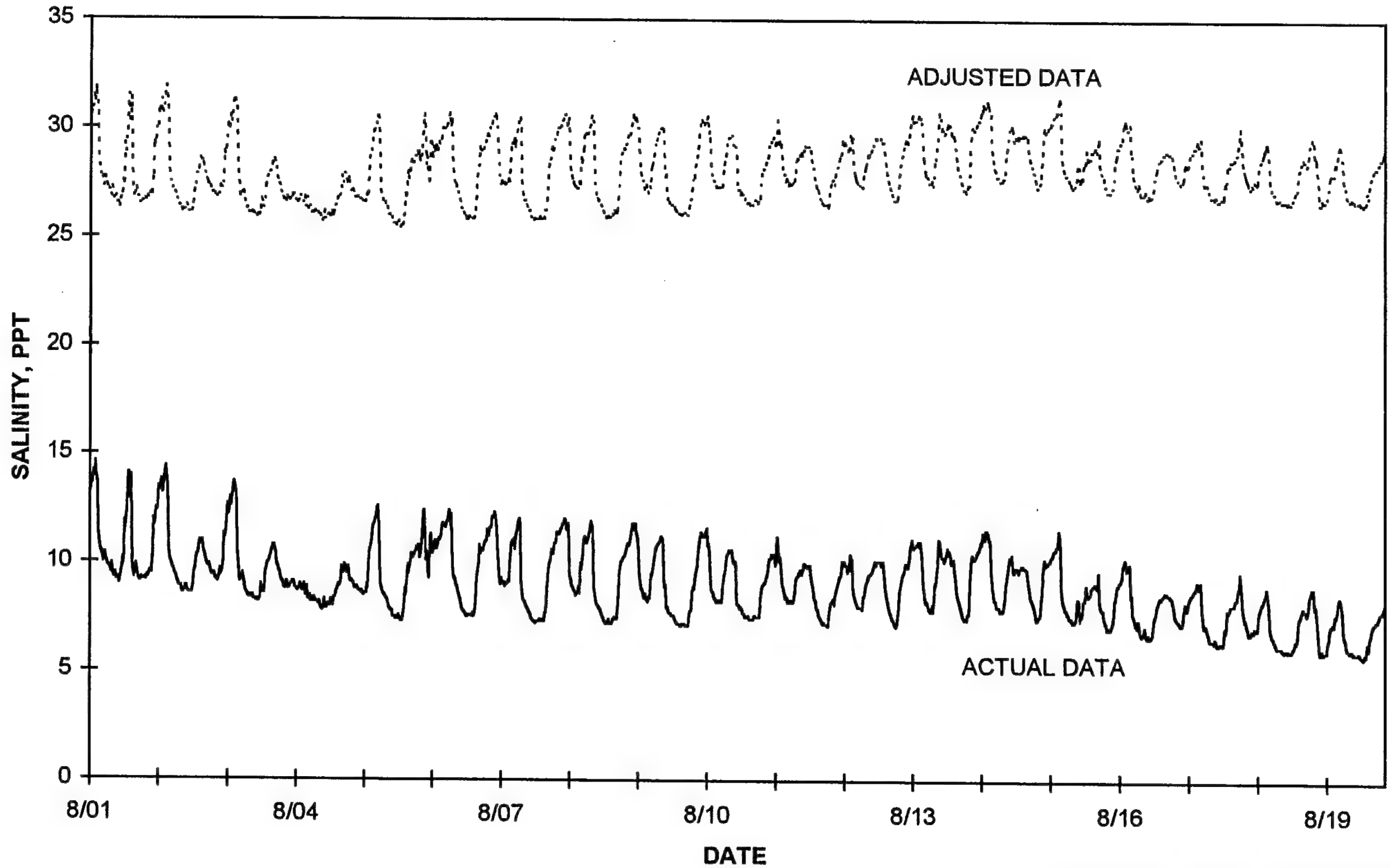
Plate 214



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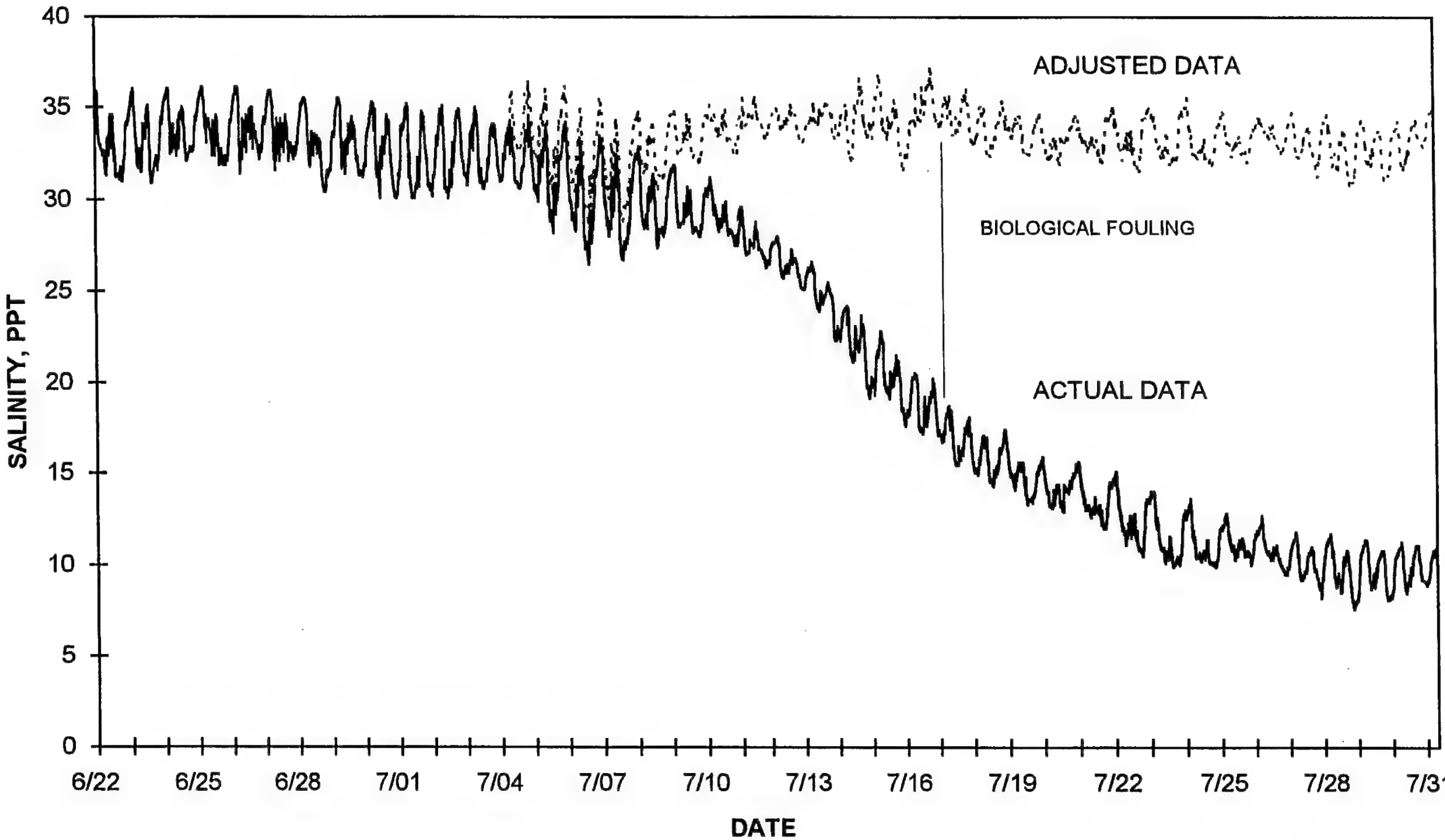
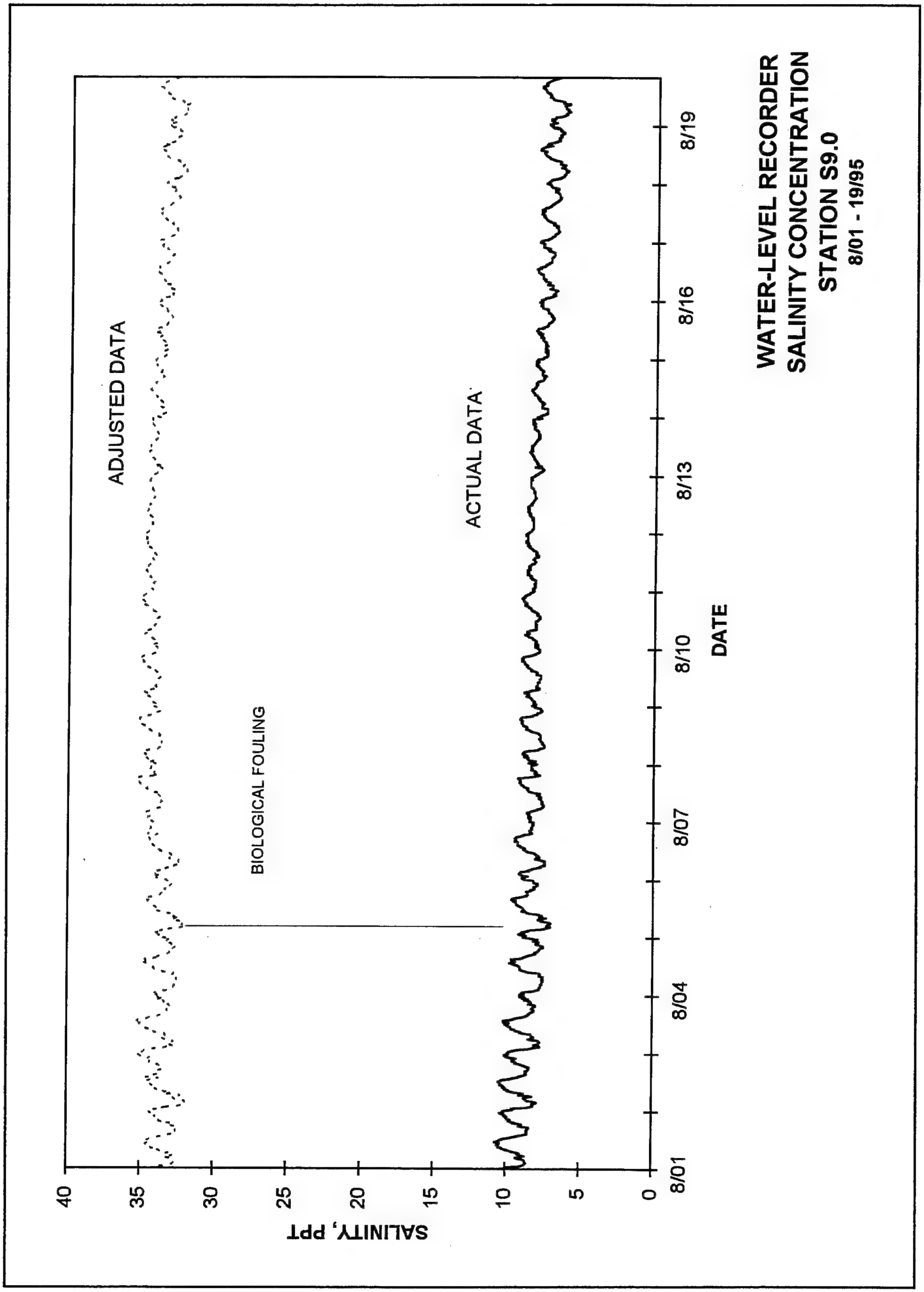


WATER-LEVEL RECORDER
SALINITY CONCENTRATION
STATION S9.0
6/22/95 - 7/31/95

Plate 216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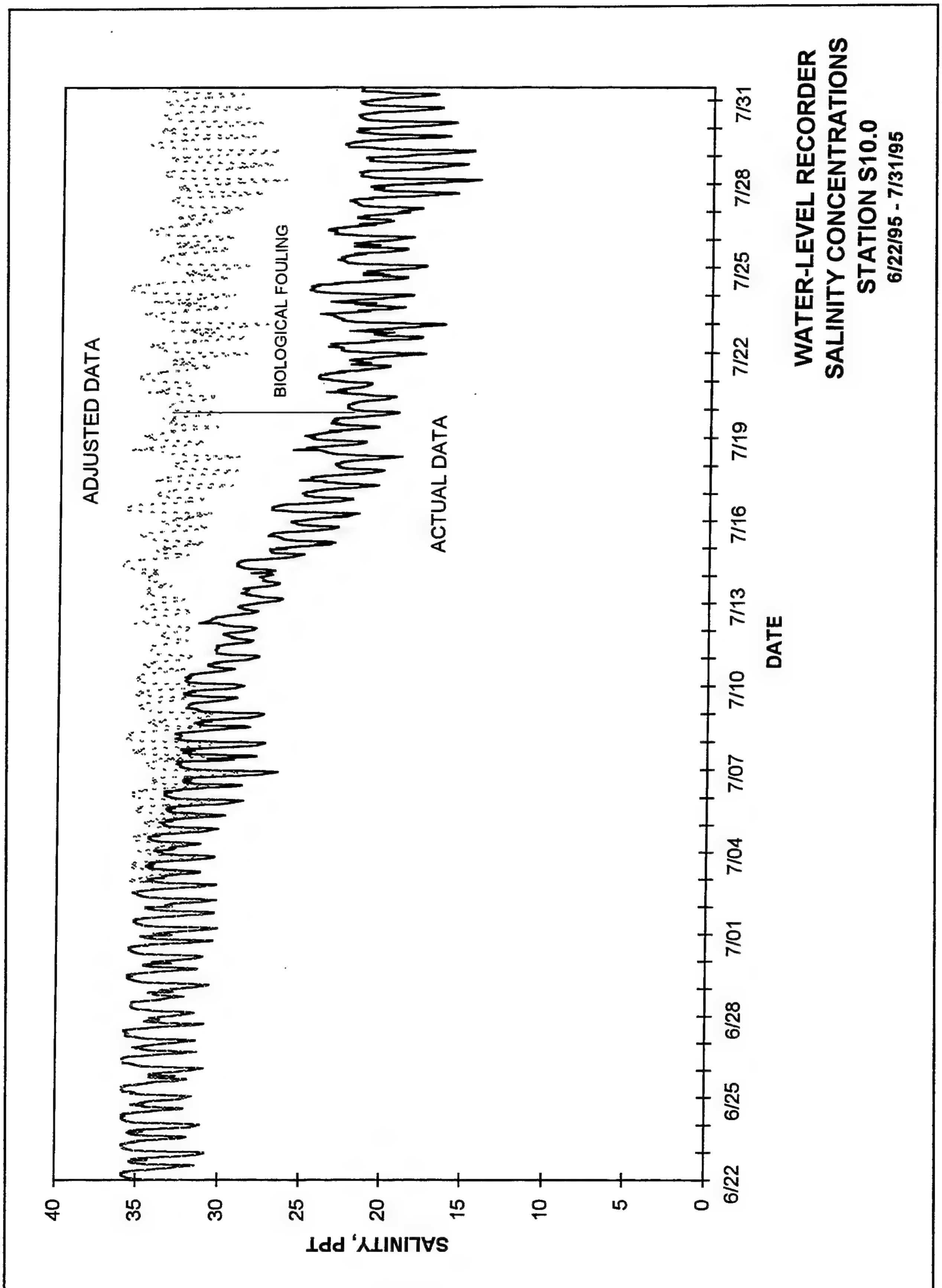

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ACTUAL DATA
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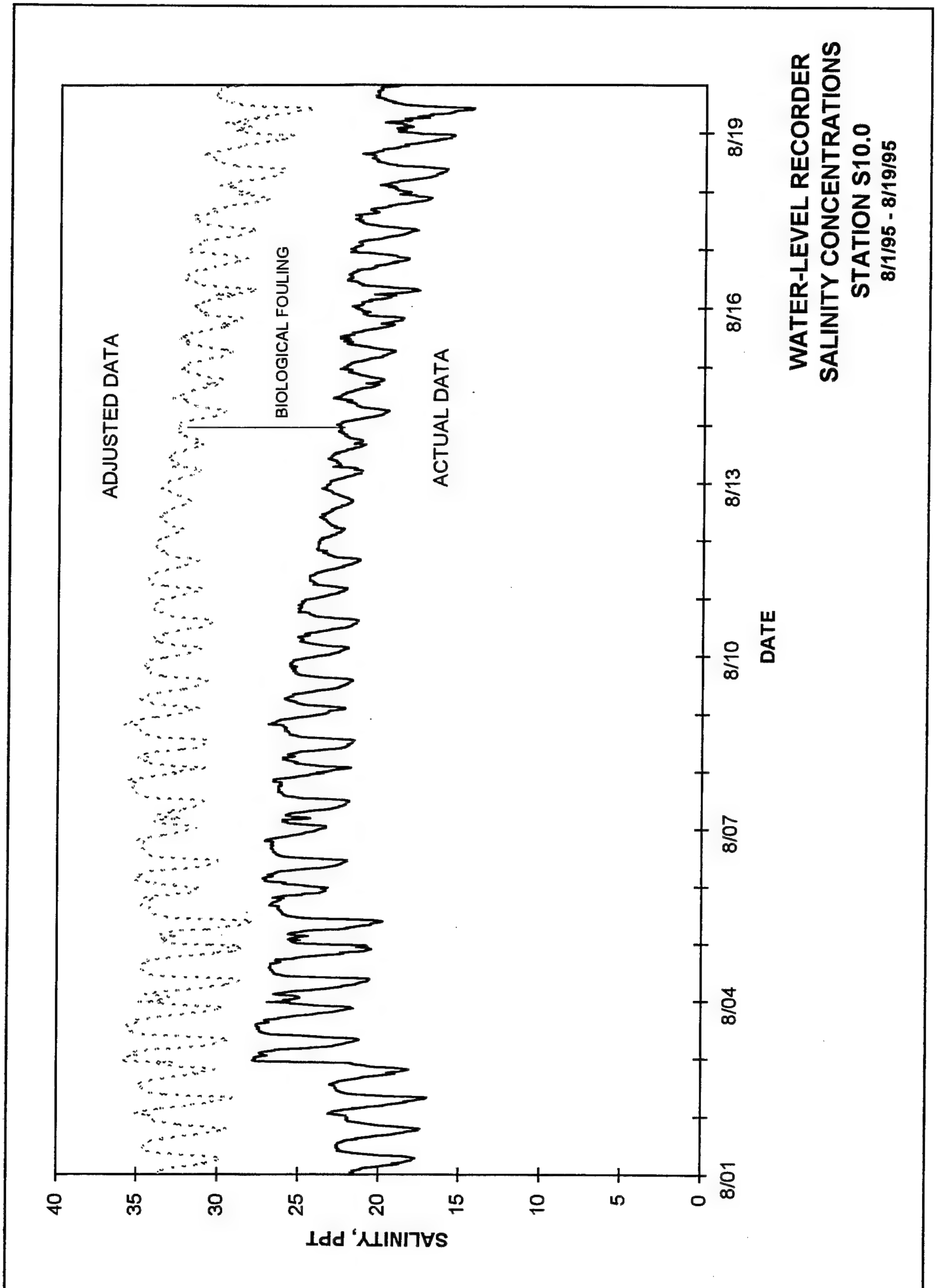
Plate 218



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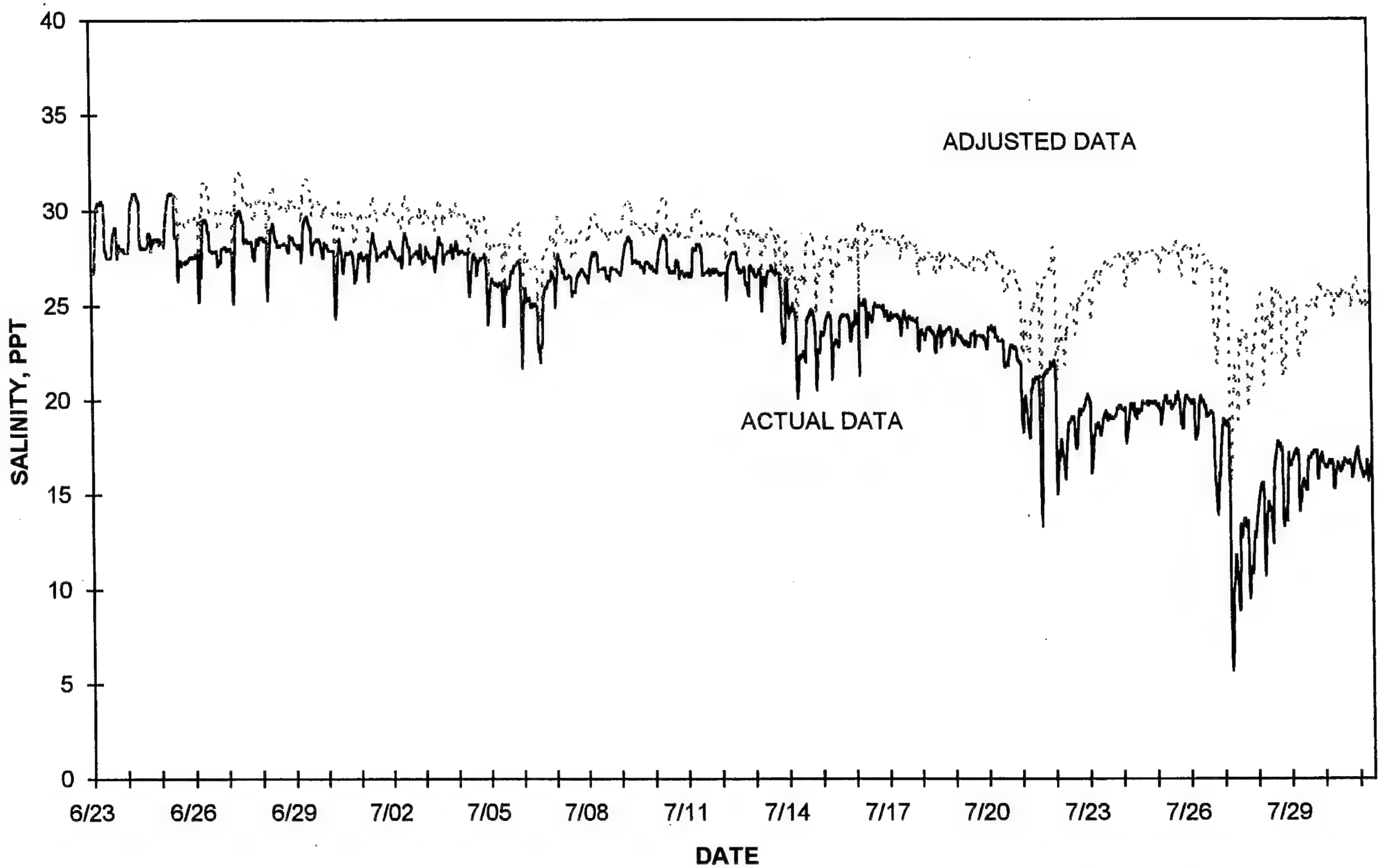
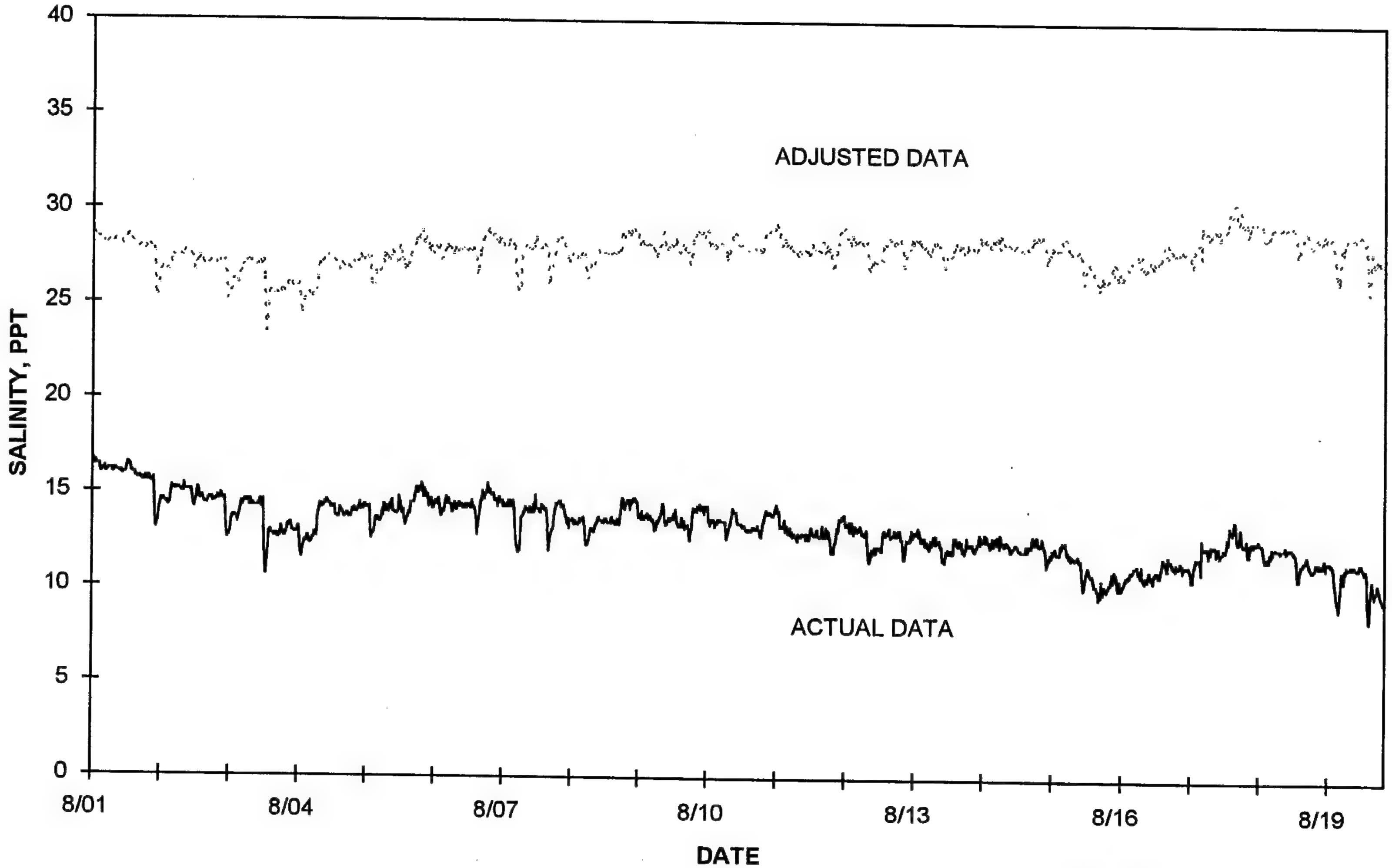


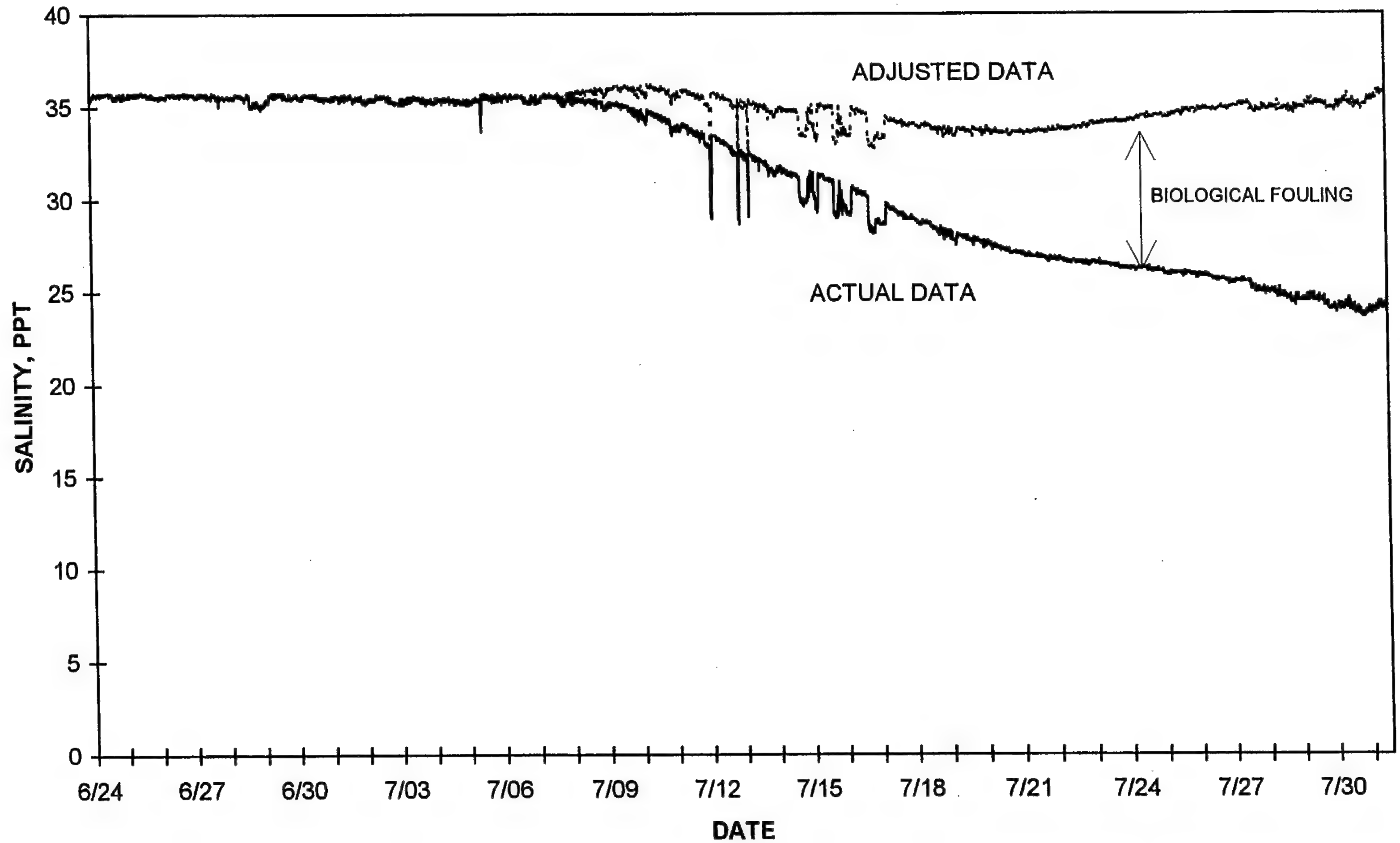
WATER-LEVEL RECORDER
SALINITY CONCENTRATIONS
STATION S11.0
6/23/95 - 7/31/95

Plate 220



WATER-LEVEL RECORDER SALINITY CONCENTRATIONS STATION S11.0

8/1/95 - 8/20/95



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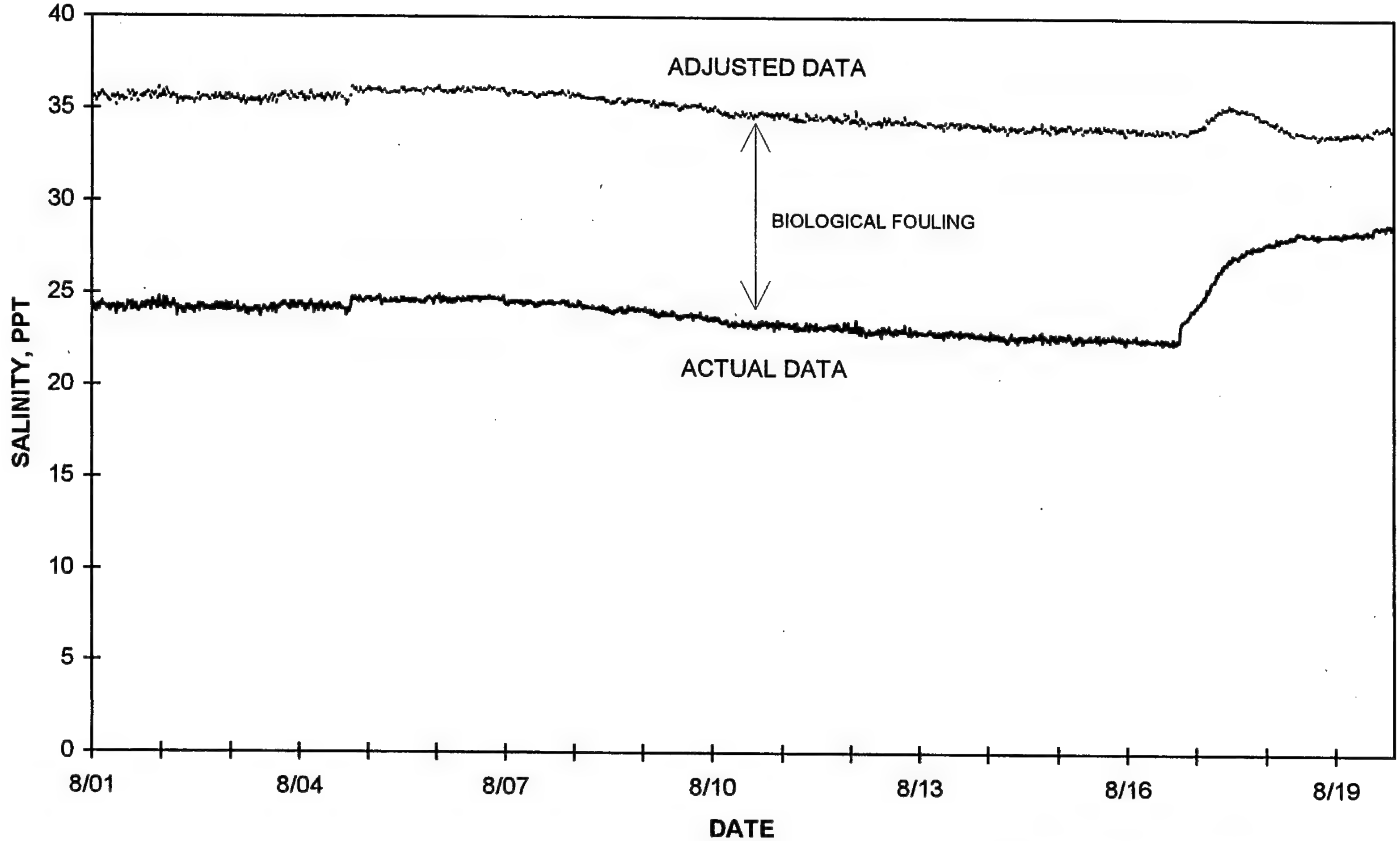

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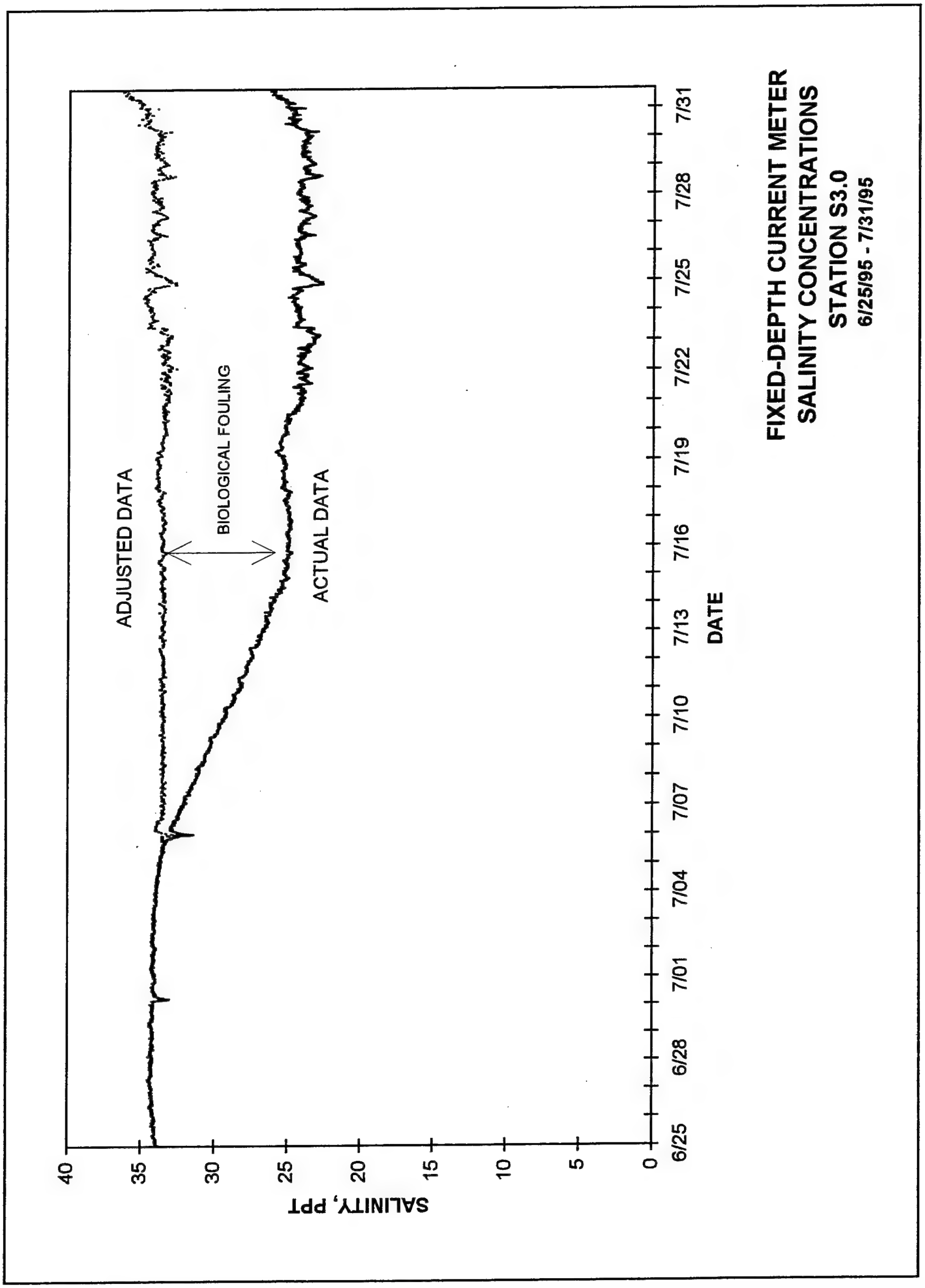
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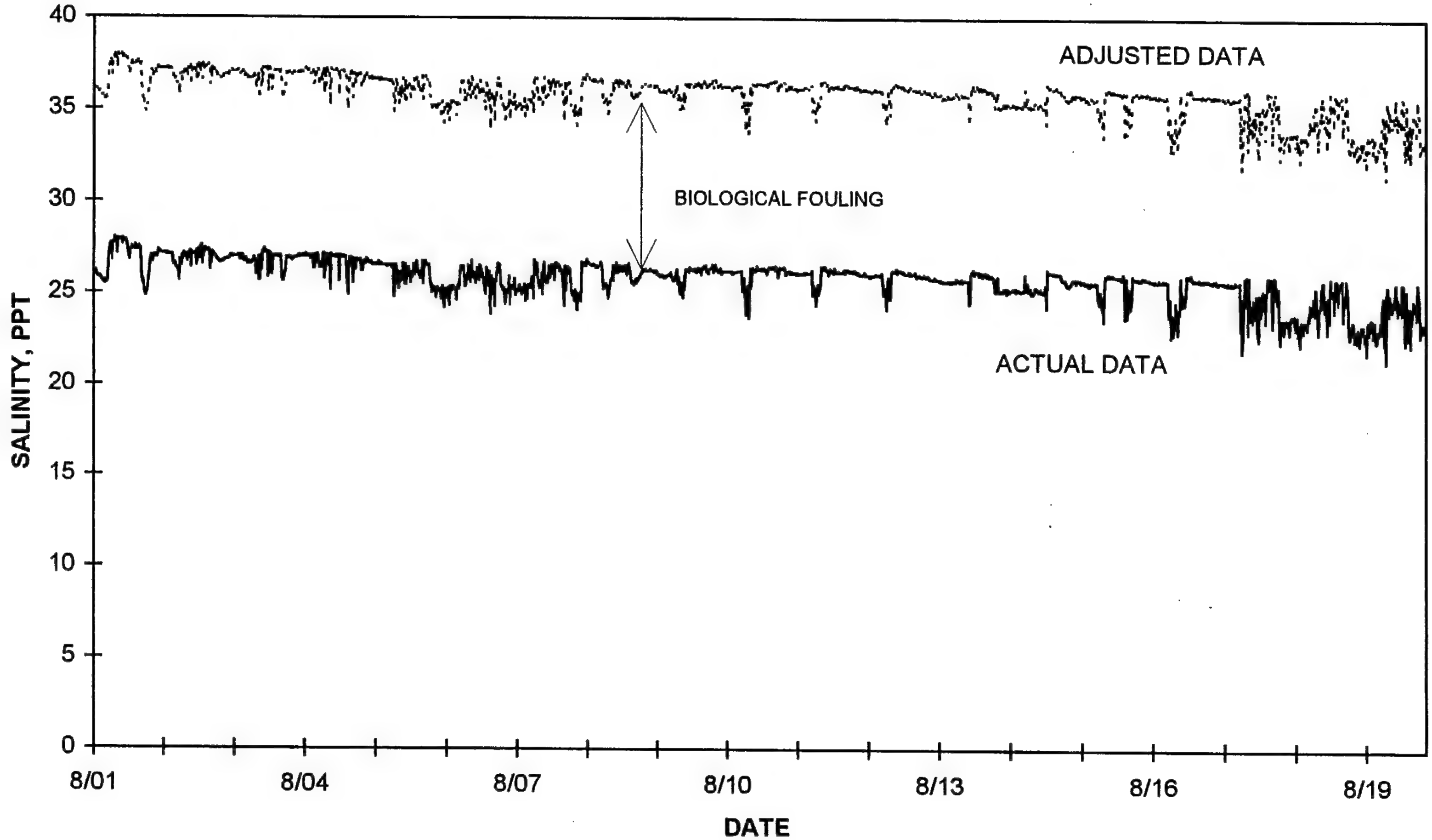
Plate 224



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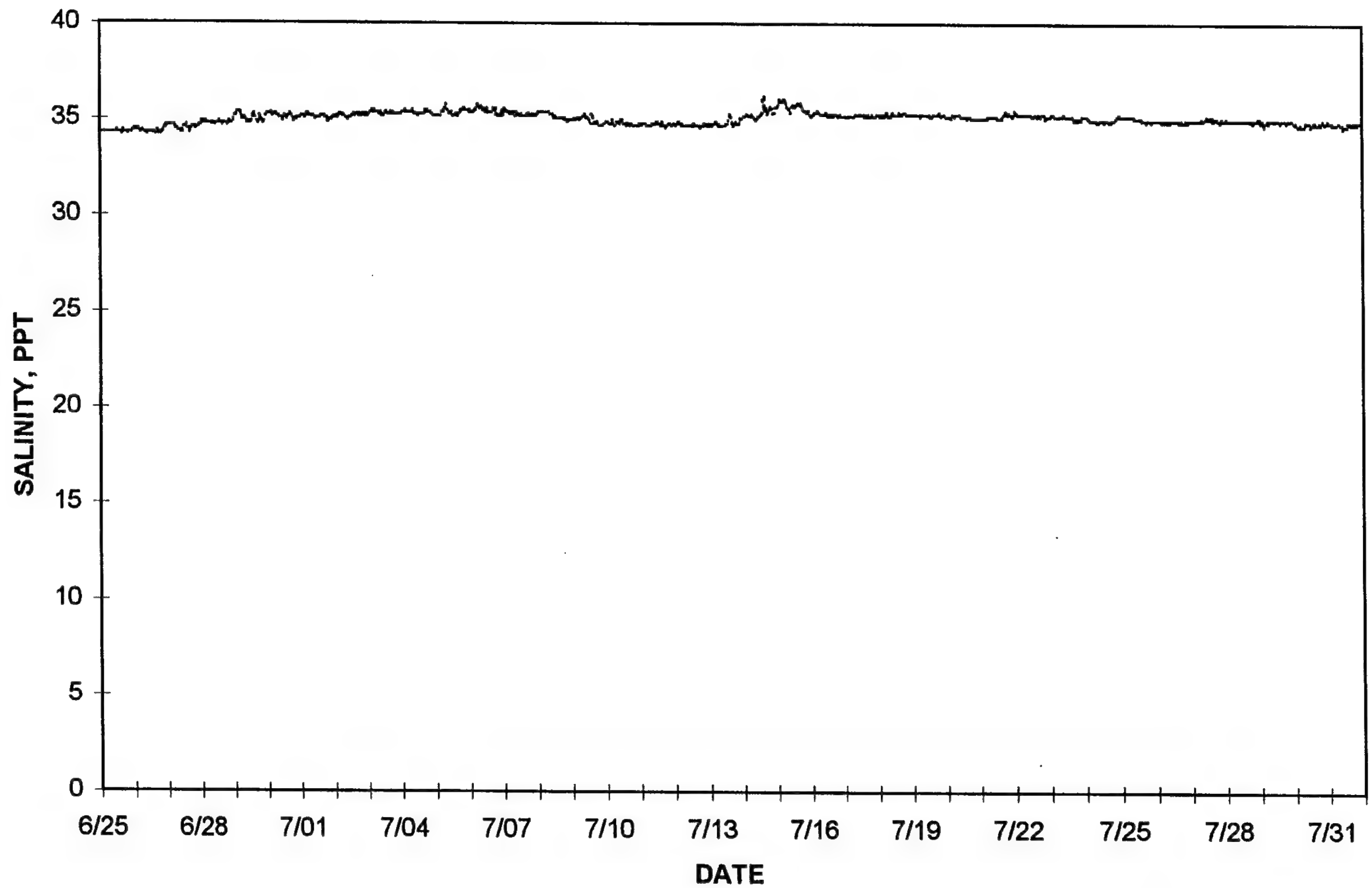
SALINITY CONCENTRATIONS
STATION S3.0
8/01 - 19/95



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SALINITY CONCENTRATIONS
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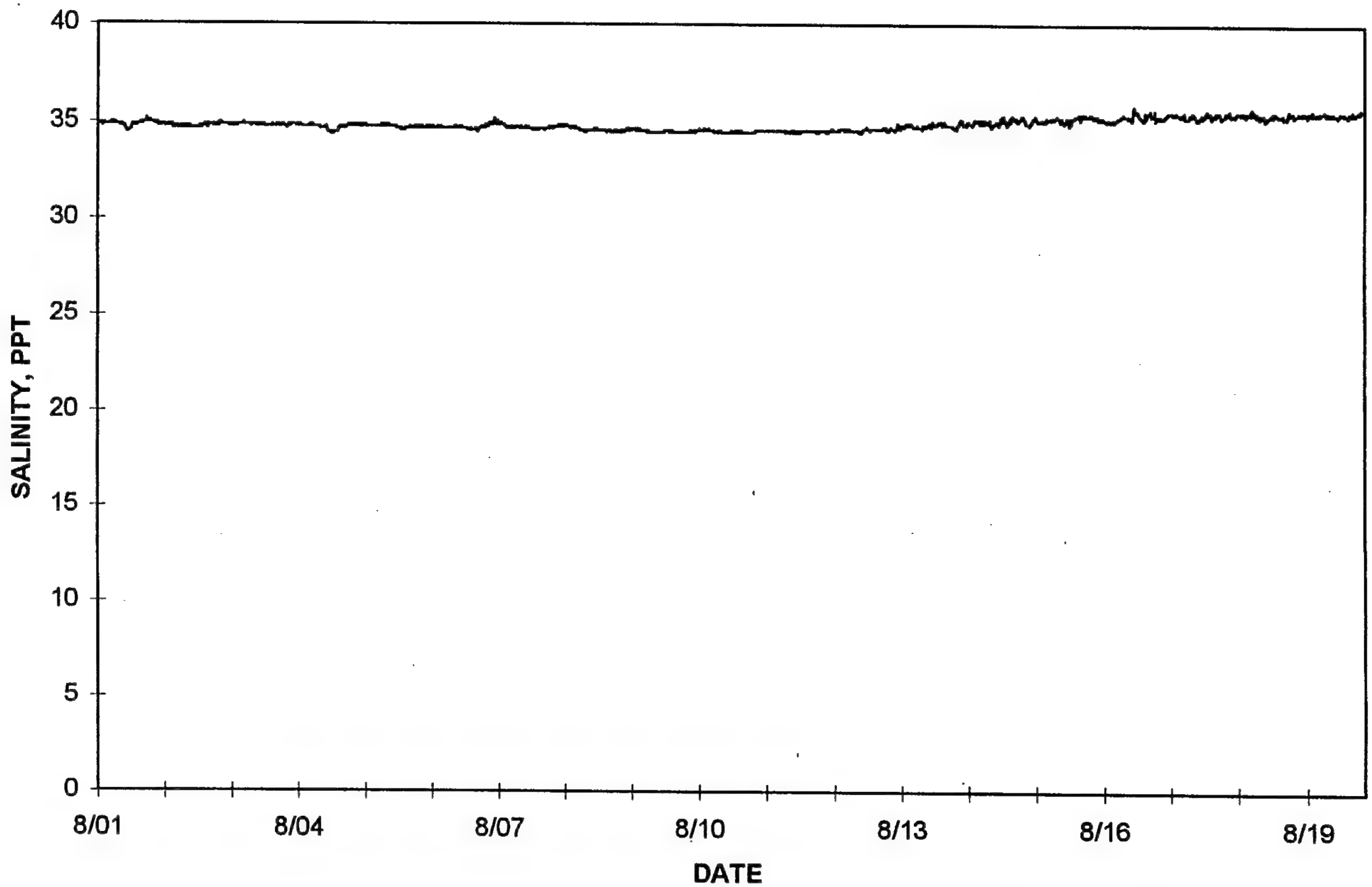

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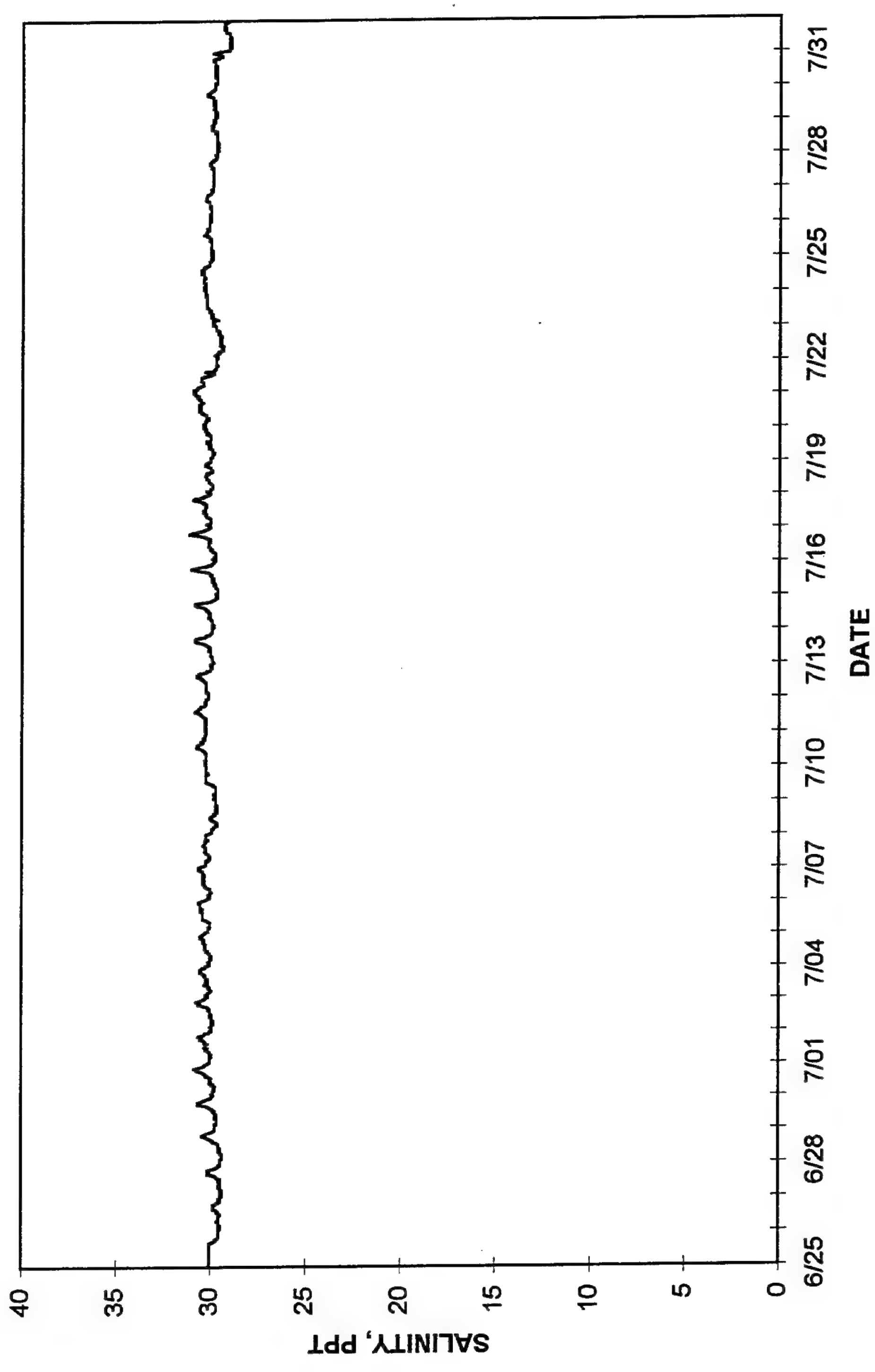

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SALINITY CONCENTRATIONS
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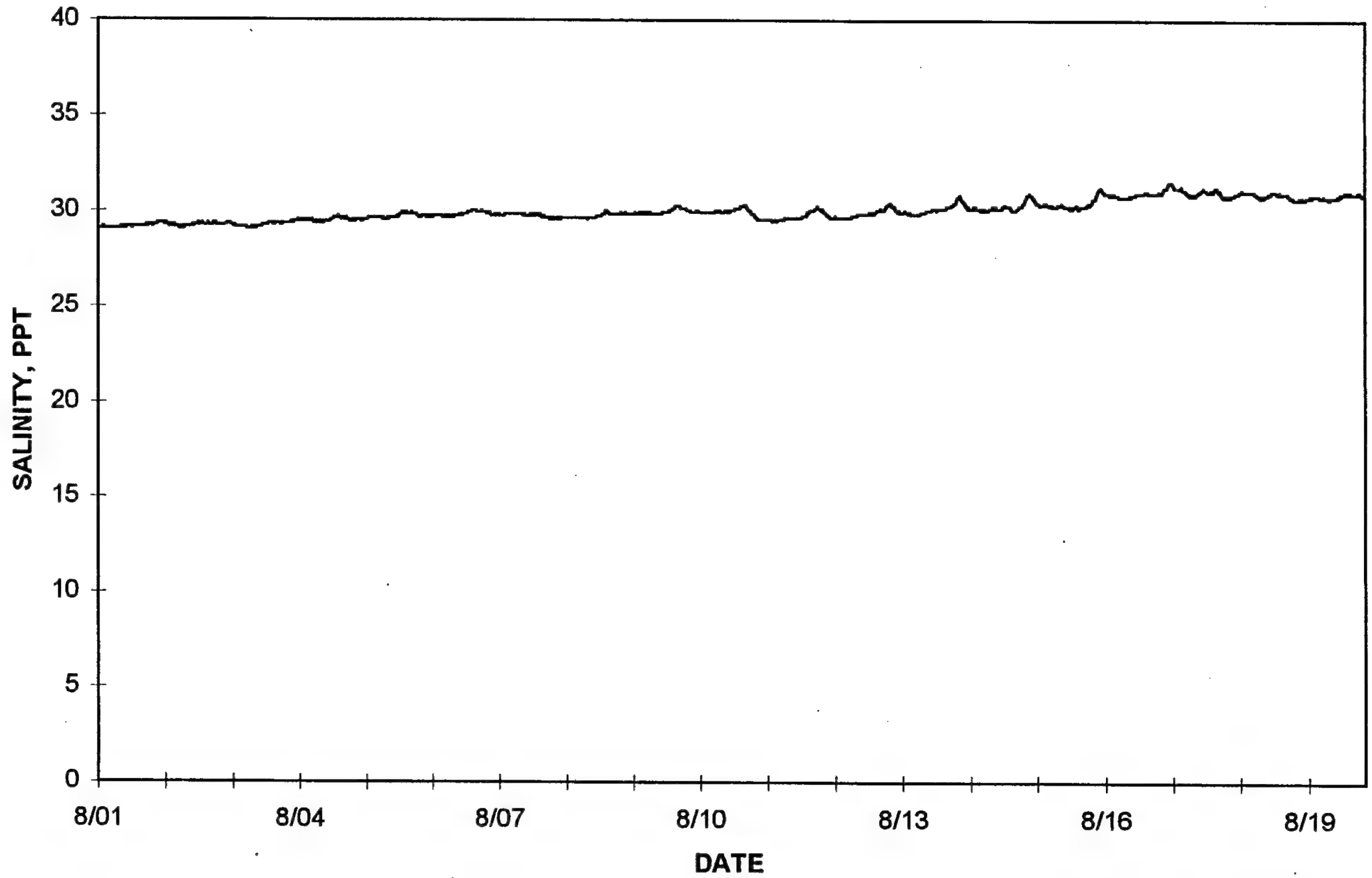

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SALINITY CONCENTRATIONS
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8/01 - 19/95

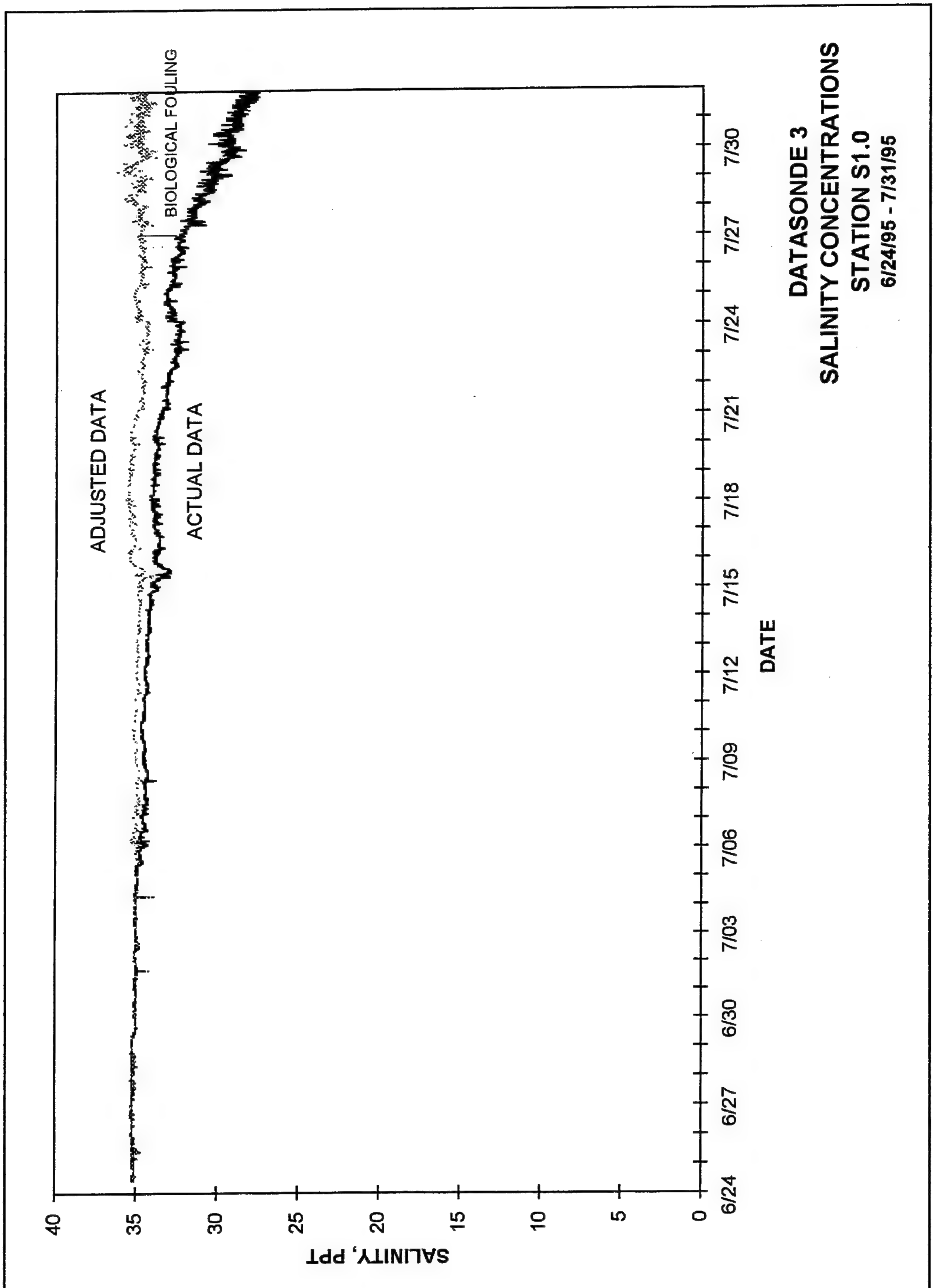
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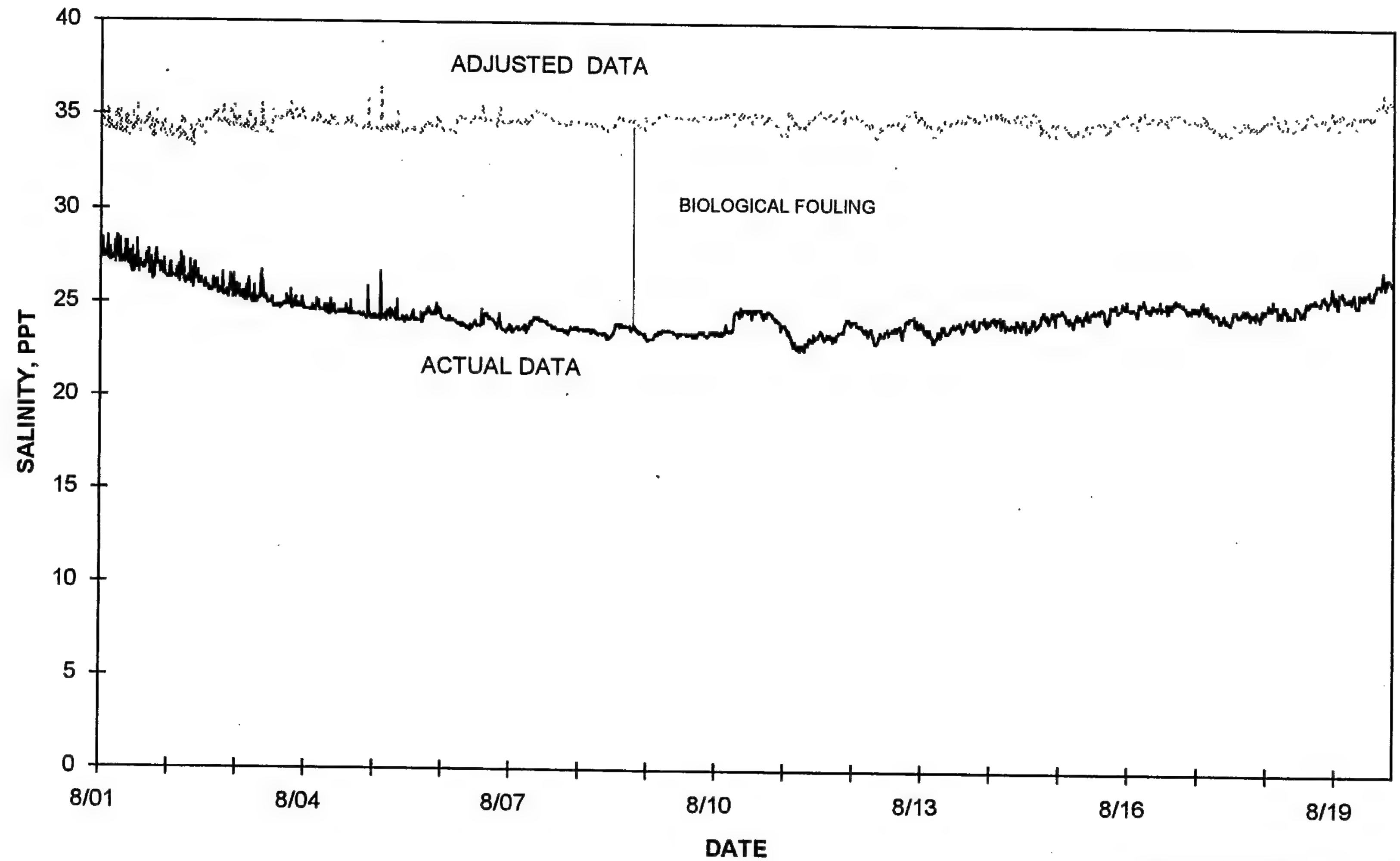
Plate 230



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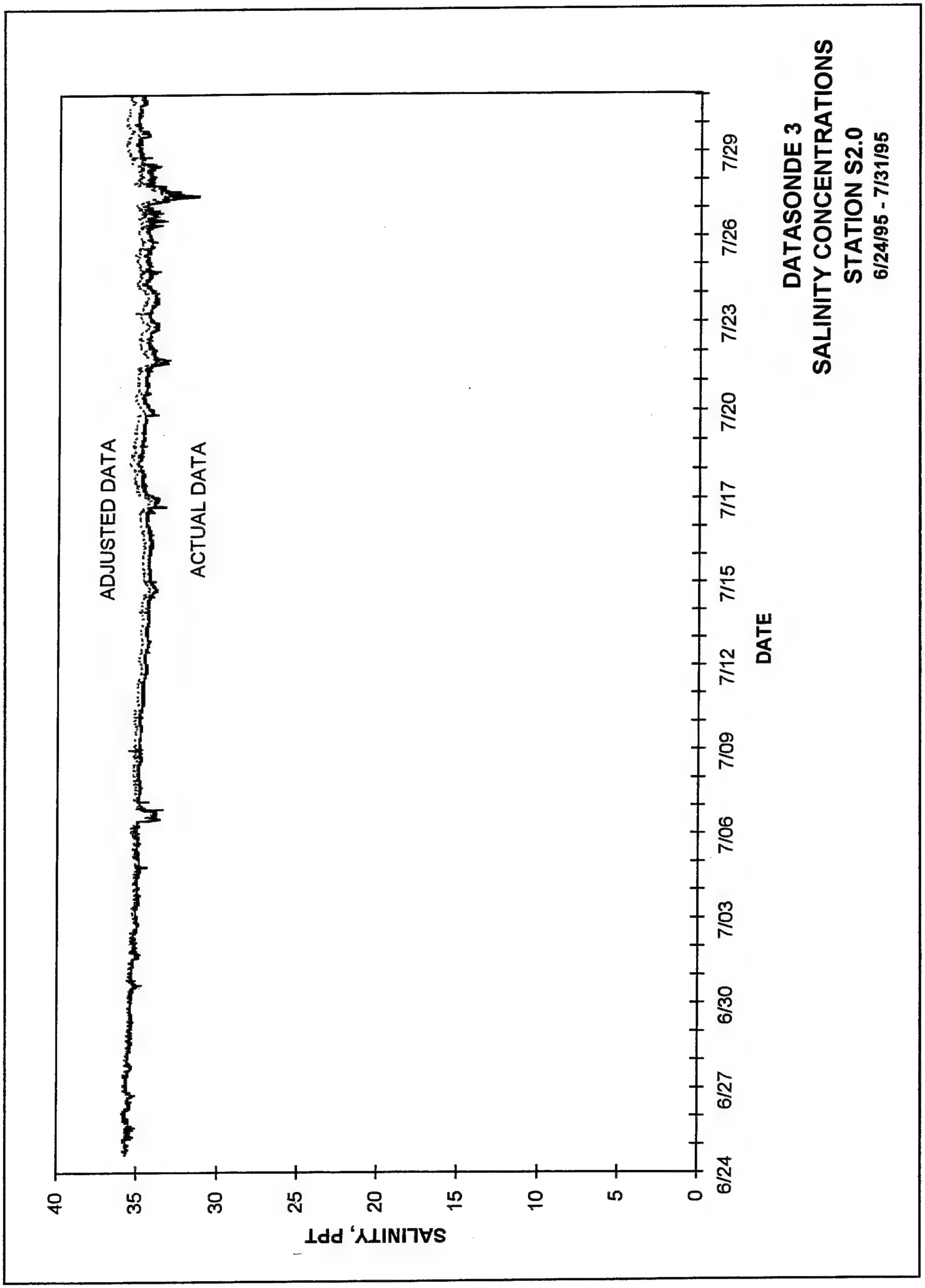

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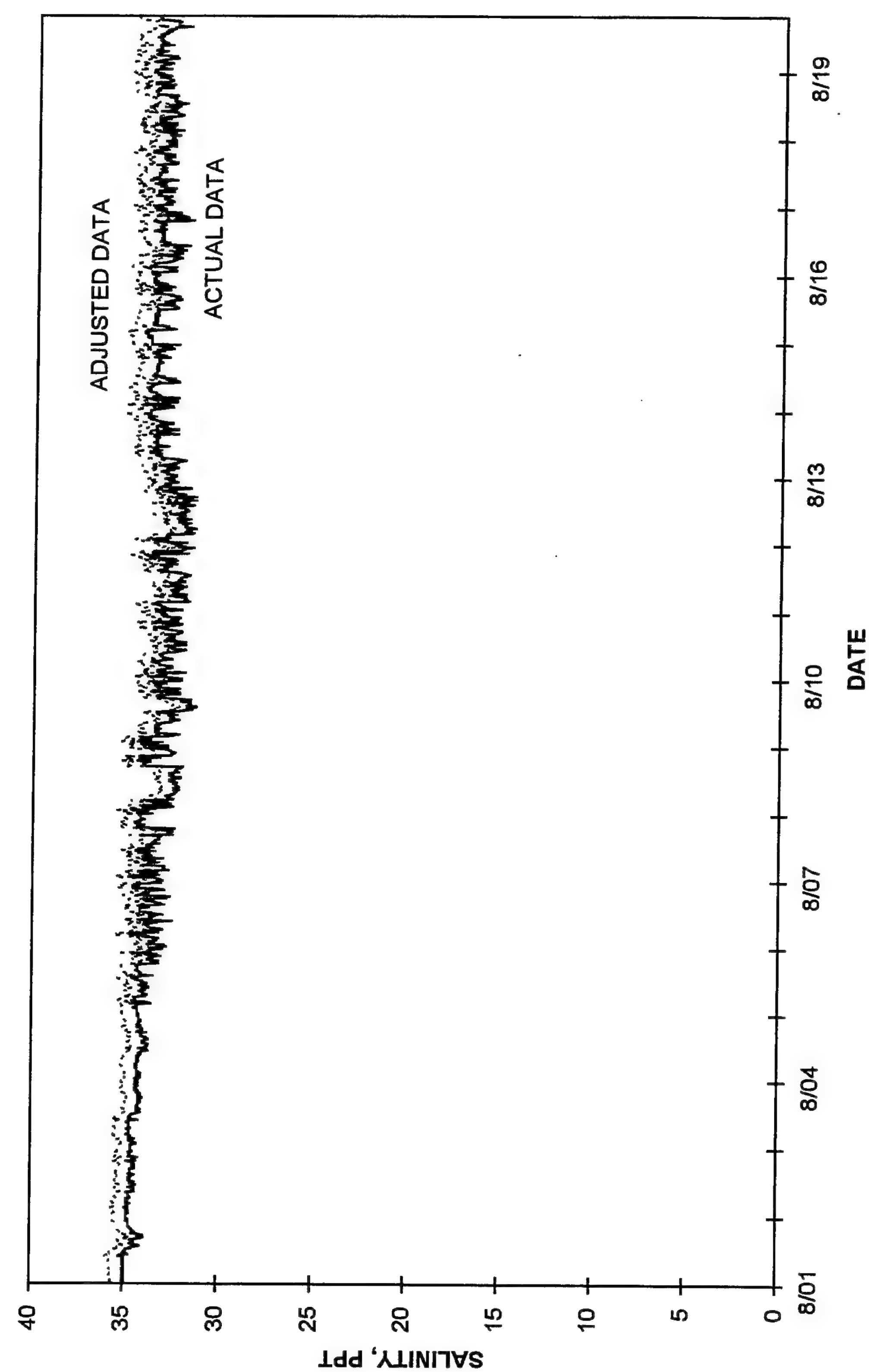
Plate 232



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STATION S2.0
8/1/95 - 8/20/95

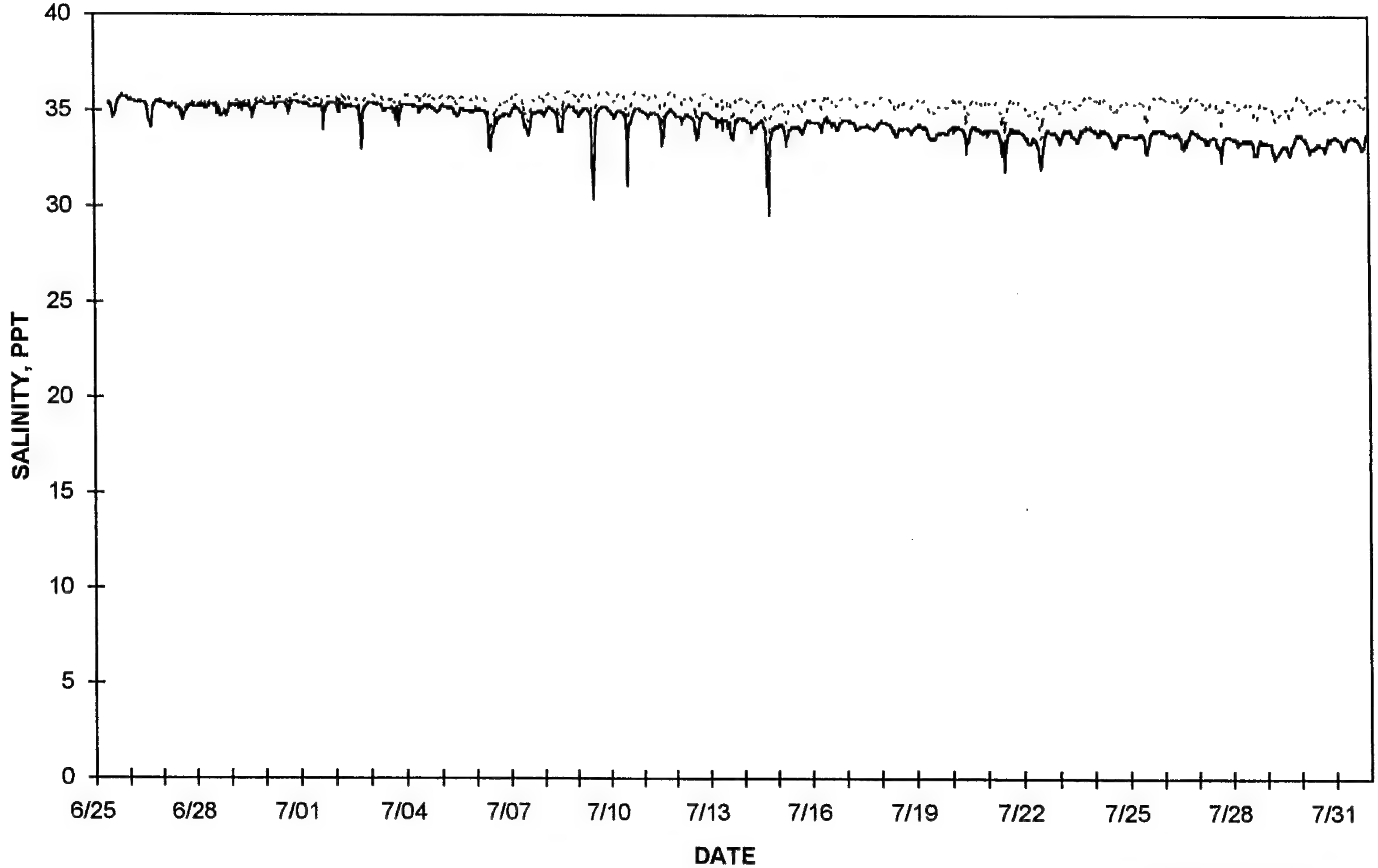

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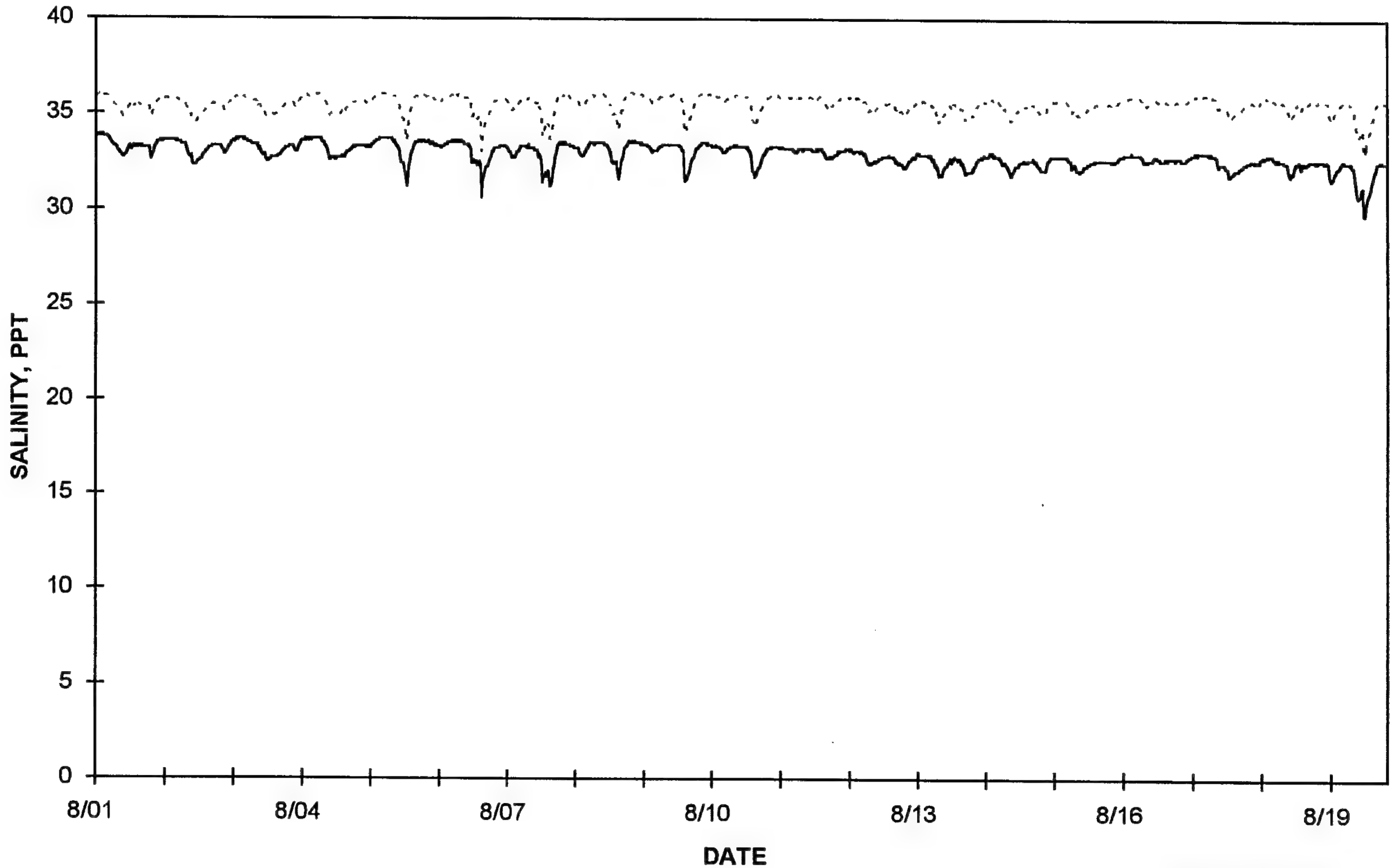
Plate 234



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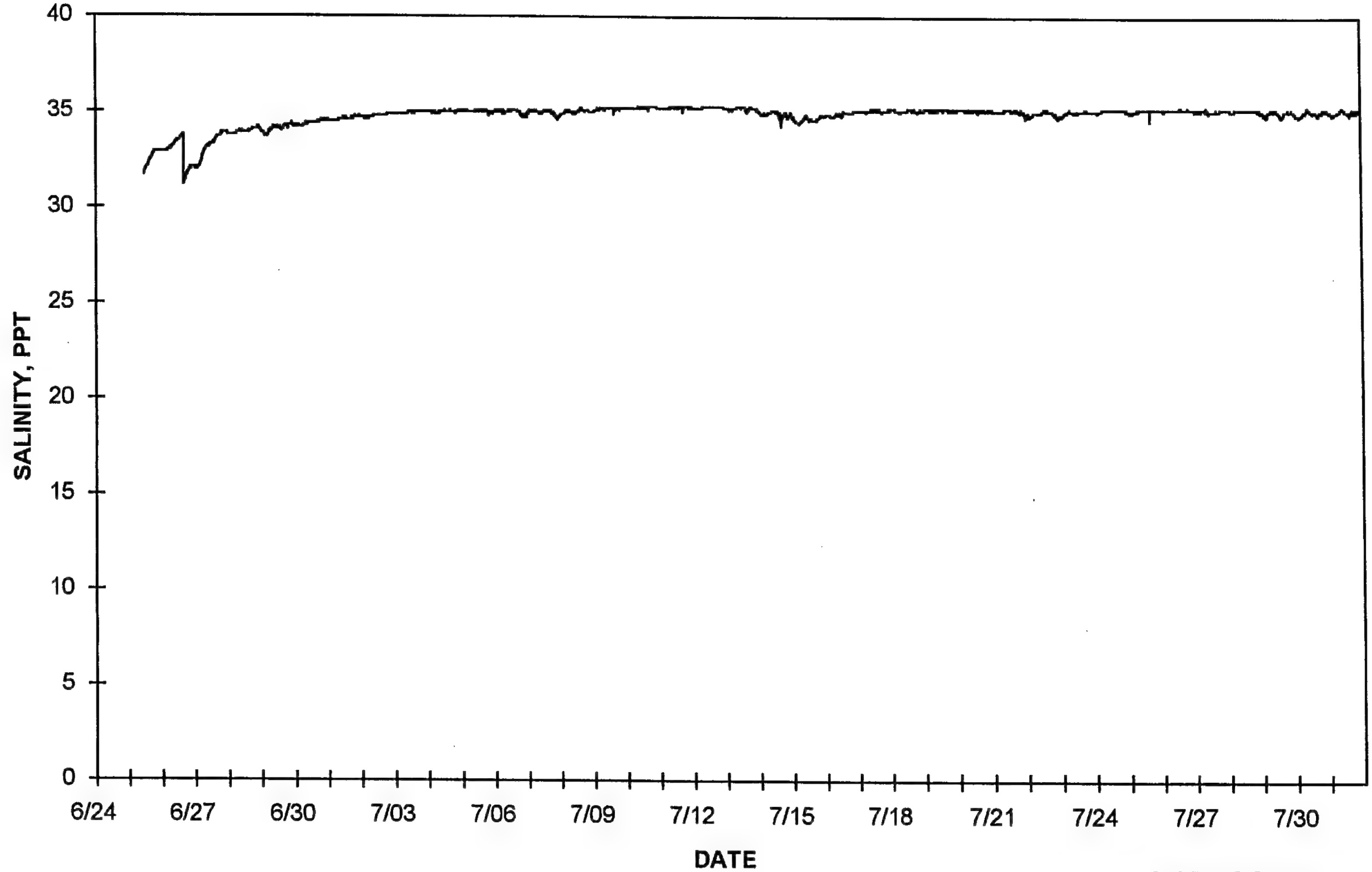
8/1/95 - 8/20/95



DATASONDE 3
SALINITY CONCENTRATIONS
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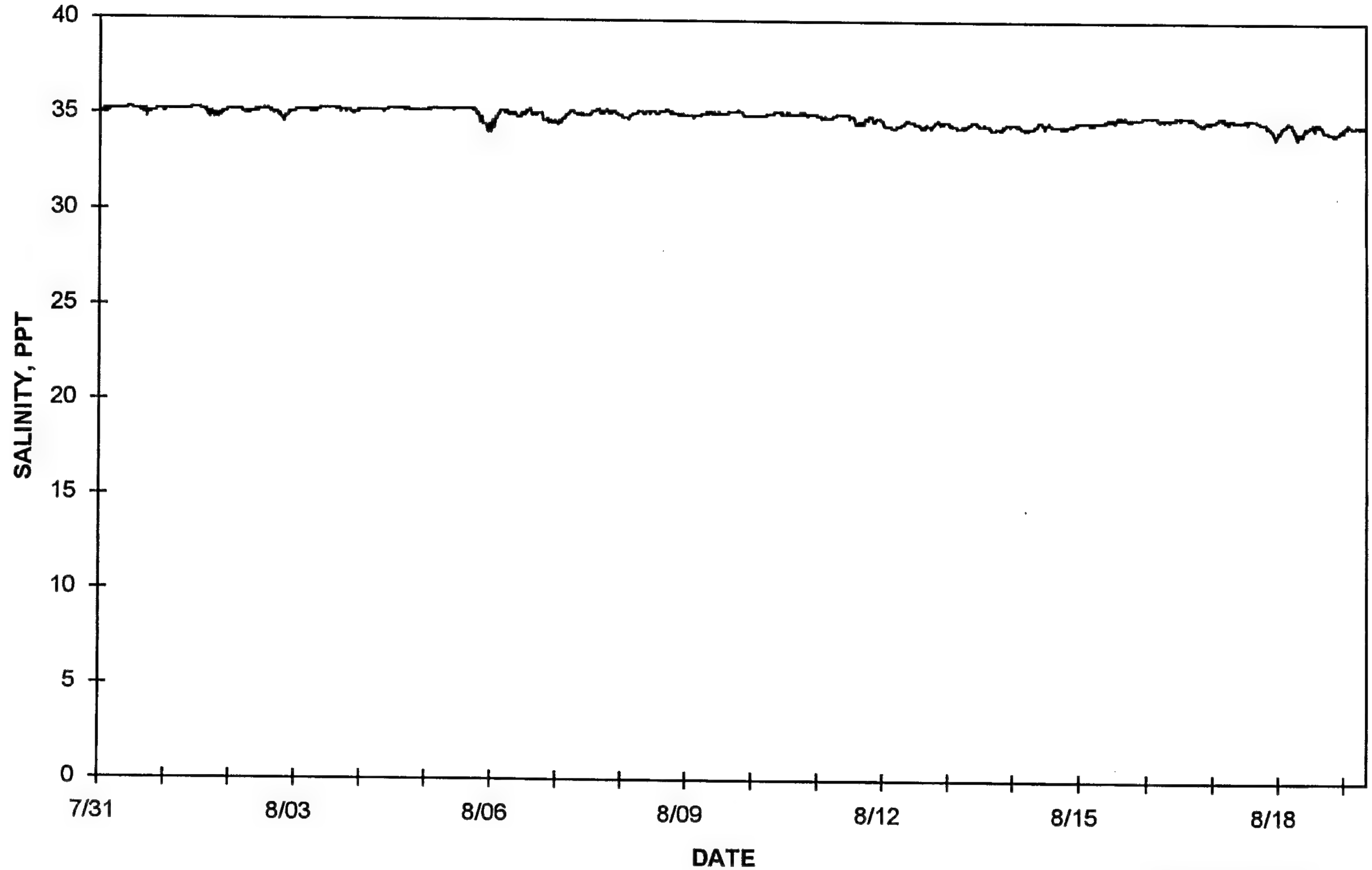
Plate 236



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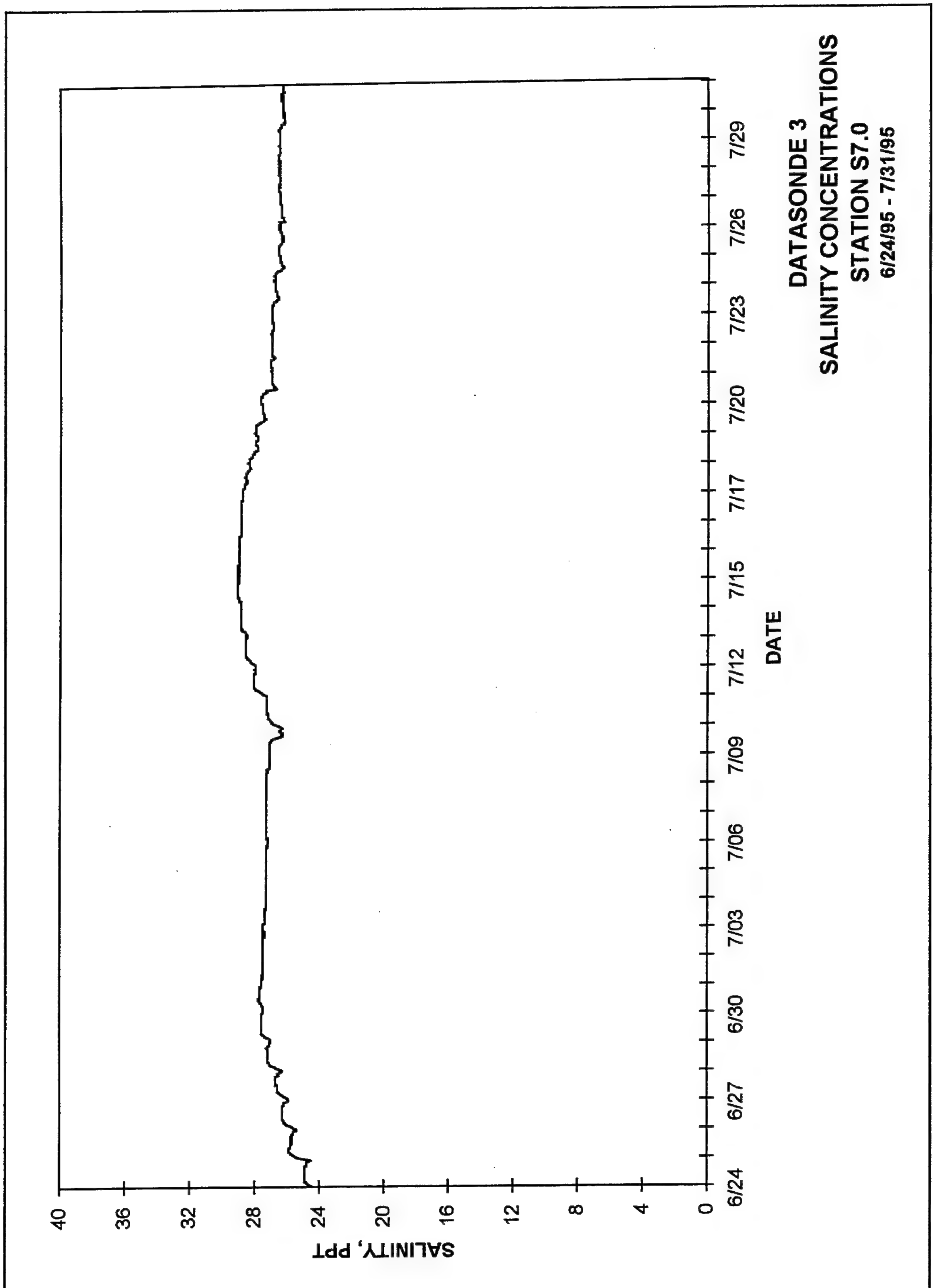
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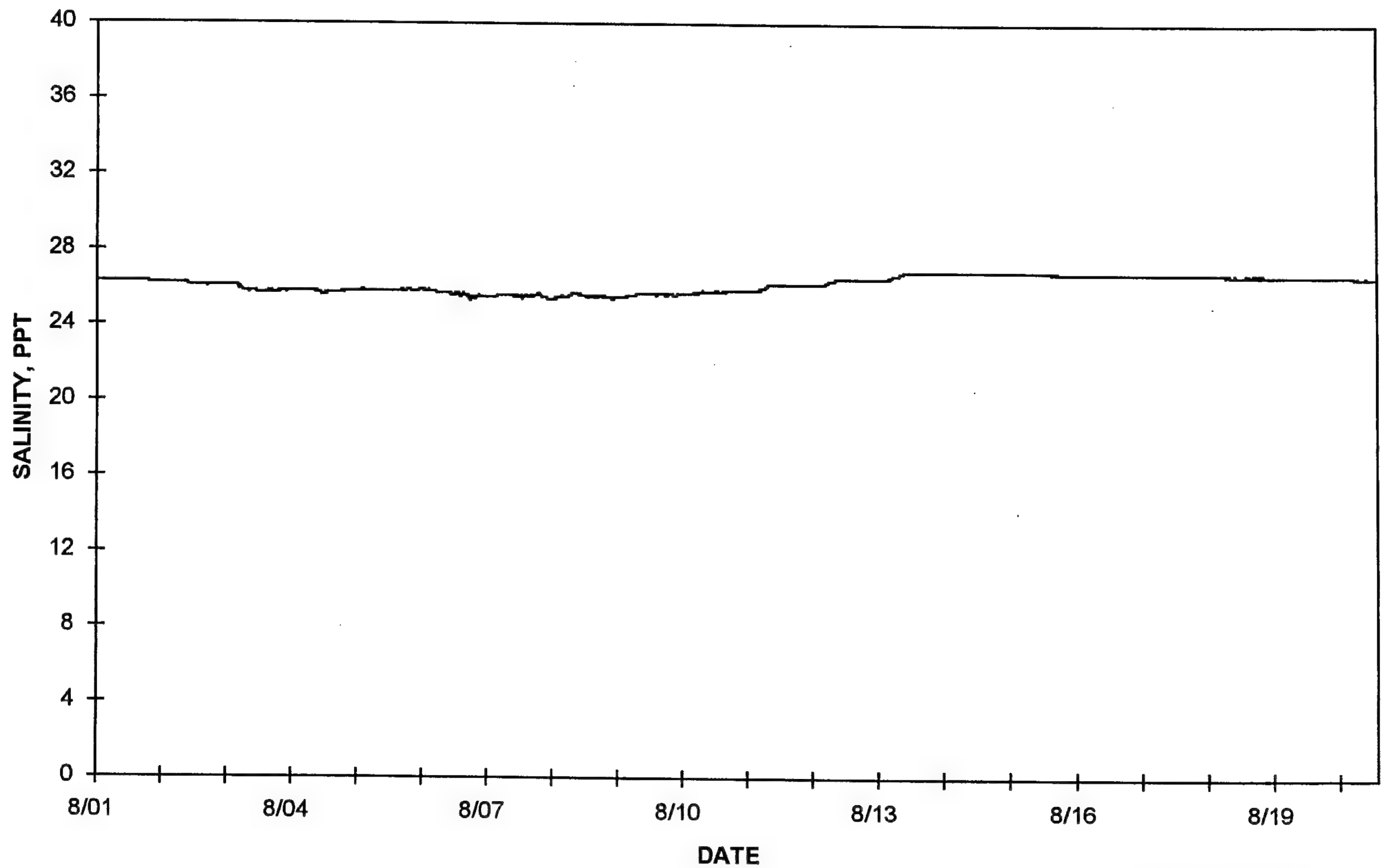
Plate 238



DATASONDE 3
SALINITY CONCENTRATIONS
STATION S7.0
8/01/95 - 8/20/95

APPENDIX A

HYDRAULIC ANALYSIS GROUP DATA COLLECTION EQUIPMENT AND LABORATORY ANALYSIS PROCEDURES

The contents of this appendix are to provide detailed information on the types of data collection and laboratory equipment used in a majority of the field investigations performed by the Hydraulic Analysis Group (HAG), Coastal Hydraulics Laboratory (CHL), of the US Army Engineer Waterways Experiment Station (USAEWES). The following table is provided to identify the parameters most commonly measured and the types of instruments which can provide these measurements.

Table A1

Current Velocity and Direction Measurements

Acoustic Doppler Current Meters

Acoustic techniques are used to obtain current velocity and direction measurements for fast and accurate profiling in the field. The equipment used are RD Instruments BroadBand Acoustic Doppler Current Profilers (ADCPs) and SonTek Acoustic Doppler Profilers (ADPs), as shown in Figure A1 and A2, respectively. These RDI instruments vary in operating frequency ranges from 150-1200 kHz, where as, the SonTek instruments have frequency ranges from 75 - 3000 kHz . The equipment can be mounted over the side of boat with the acoustic transducers submerged and data is collected while the vessel is underway as shown in Figure A3. It can also be mounted on a stable platform and placed on the riverbed or seabed as shown in Figure A4.

The ADCP and ADP transmits sound bursts into the water column which are scattered back to the instrument by particulate matter suspended in the flowing water. The ADCP and ADP sensors listens for the returning signal and assigns depths and velocity to the received signal based on the change in the frequency caused by the moving particles. This change in frequency is referred to as a Doppler shift.

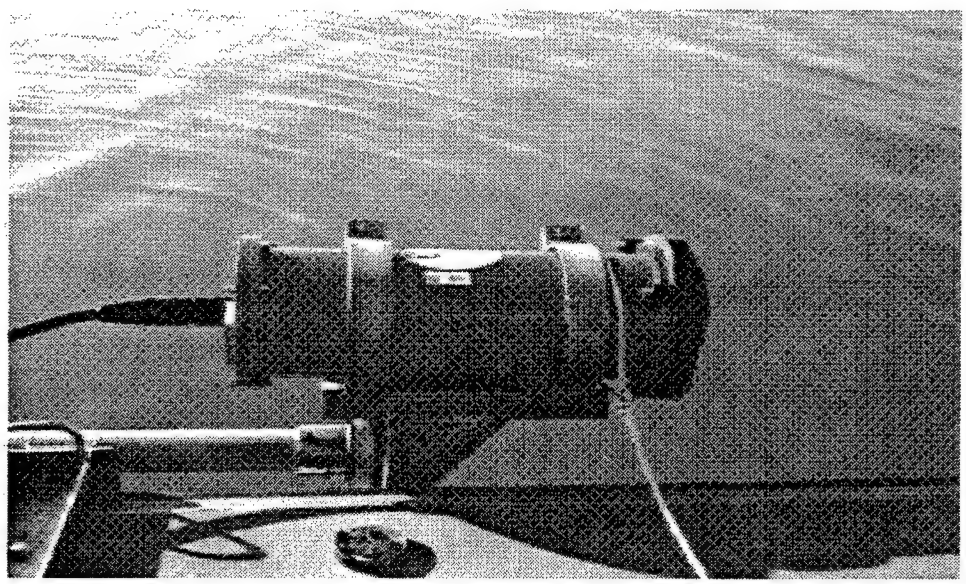


Figure A1. Acoustic Doppler Current Profiler (ADCP)

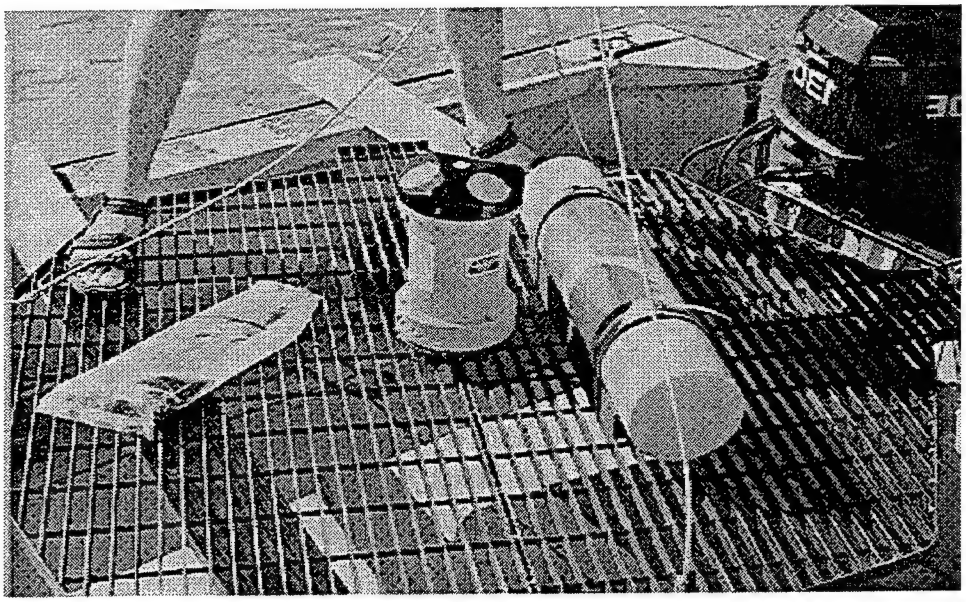


Figure A2. Acoustic Doppler Profiler (ADP)

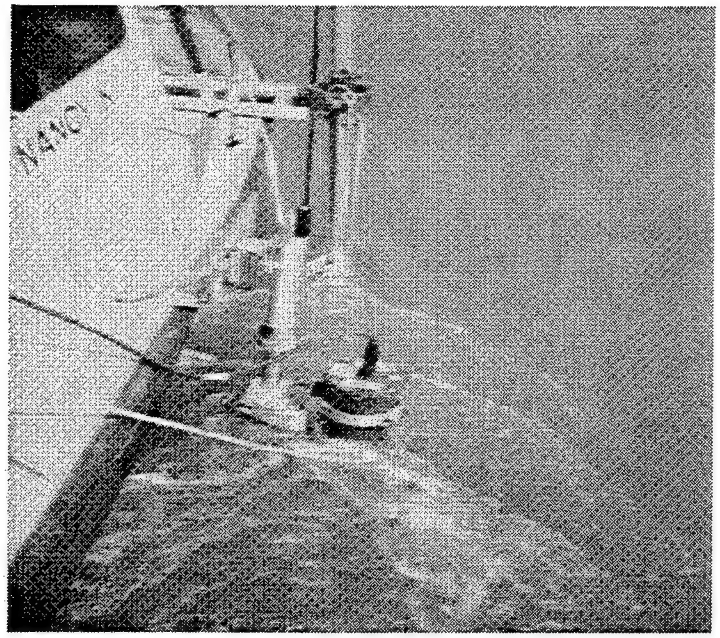


Figure A3. Vessel mounted ADCP

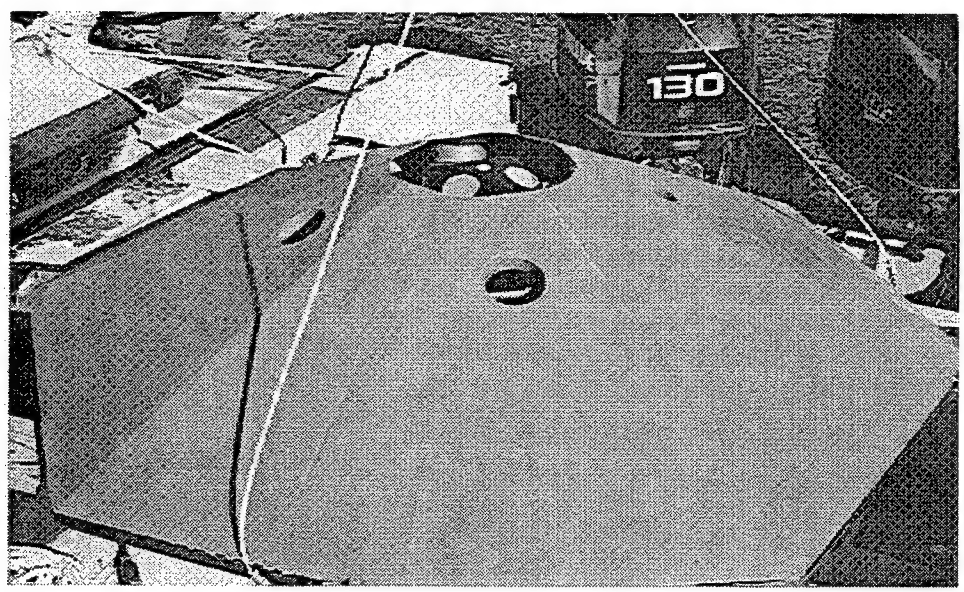


Figure A4. Bottom-mounted ADP unit

The ADCP is also capable of measuring vessel direction, current direction, water temperature, and bottom depth. Communication with the instrument for set-up and data recording are performed with a portable computer using manufacturer supplied software, hardware, and communication cables. The manufacturer stated accuracies for current speed measurement ± 2 cm/s; for vessel direction ± 2 degrees; and temperature ± 5° F.

Fixed Depth Recording Current Meter

Self-contained recording current meters are used to obtain current velocity and direction measurements for both profiling and for long term fixed-depth deployment. The Environmental Device Corporation (ENDECO) Type 174 SSM current meter, shown in figure A5, is tethered to a stationary line or structure and floats in a horizontal position at the end of the tether (as shown in Figure A6). It measures current speed with a ducted impeller and current direction with an internal compass. It also measures temperature with a thermilinear thermistor and conductivity with an induction type probe. Data are recorded on an internal solid state memory datalogger. Data is offloaded from the meter datalogger by means of a communication cable connected between the meter and a computer. The threshold speed is less than 0.08 fps, maximum speed of the unit used is 8.44 fps (10 knots), and stated speed accuracy is ± 3 percent of full scale. The manufacturer states that direction accuracy is ± 7.2 degrees above 0.08 fps. Time accuracy is ± 4 sec/day.

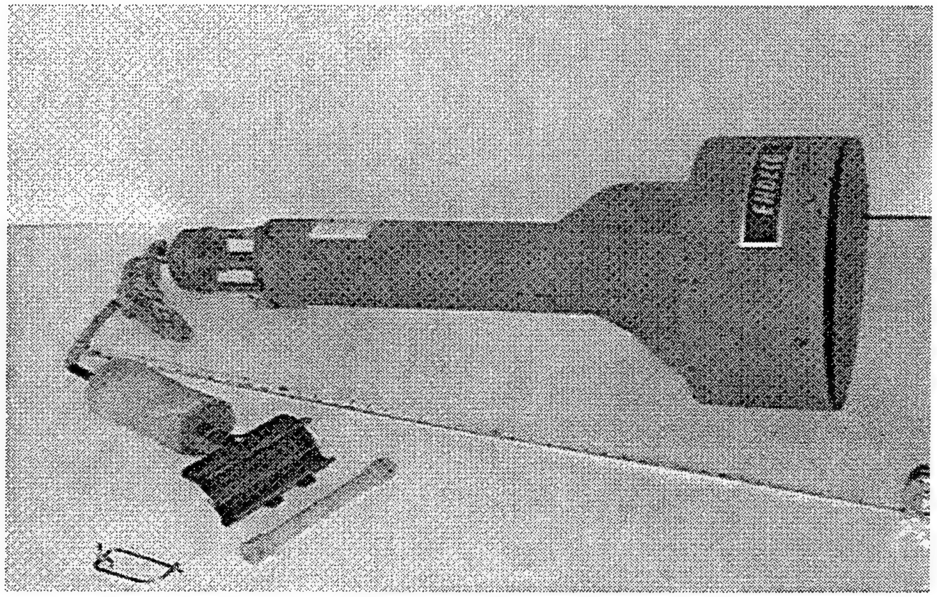


Figure A5. ENDECO Type 174 SSM Current Meter

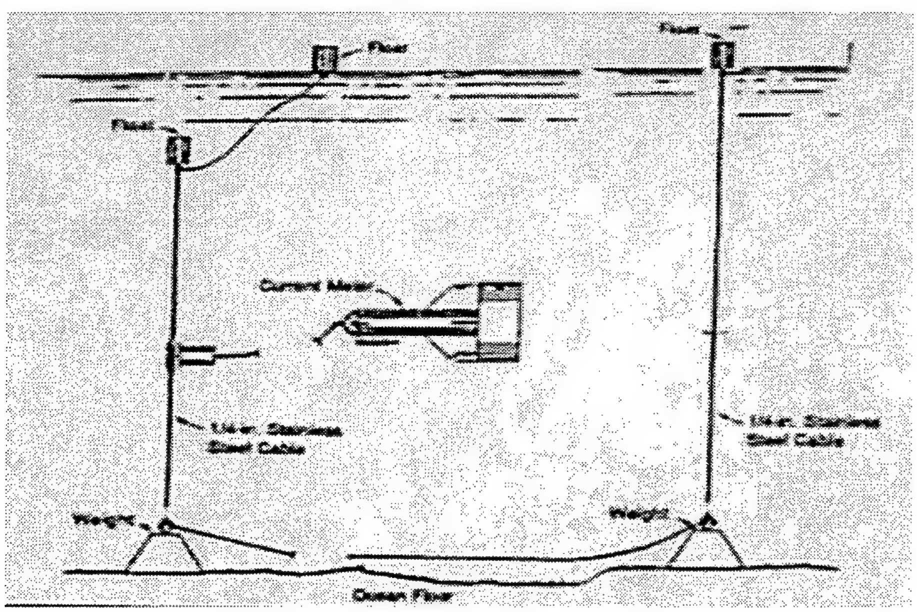


Figure A6. ENDECO 174 SSM current meter as deployed
in the field.

The InterOcean Model S4 electromagnetic current meter, shown in figure A7, can obtain continuous recording of current velocity and direction at fixed depths or can be used to profile the water column for current velocity and directions. The S4 meter is a 10 in. diameter sphere that is suspended vertically in the water column with a submerged flotation device and anchored to the bottom by a heavy block and anchor arrangement. This deployment technique is illustrated in Figure A8. The S4 meter measures the current velocity using an electromagnetic microprocessor coupled with an internal flux-gate compass computes the velocity vectors, which are then stored in the solid state memory. The accuracy of the S4 meter current speed is ± 0.2 cm/sec.

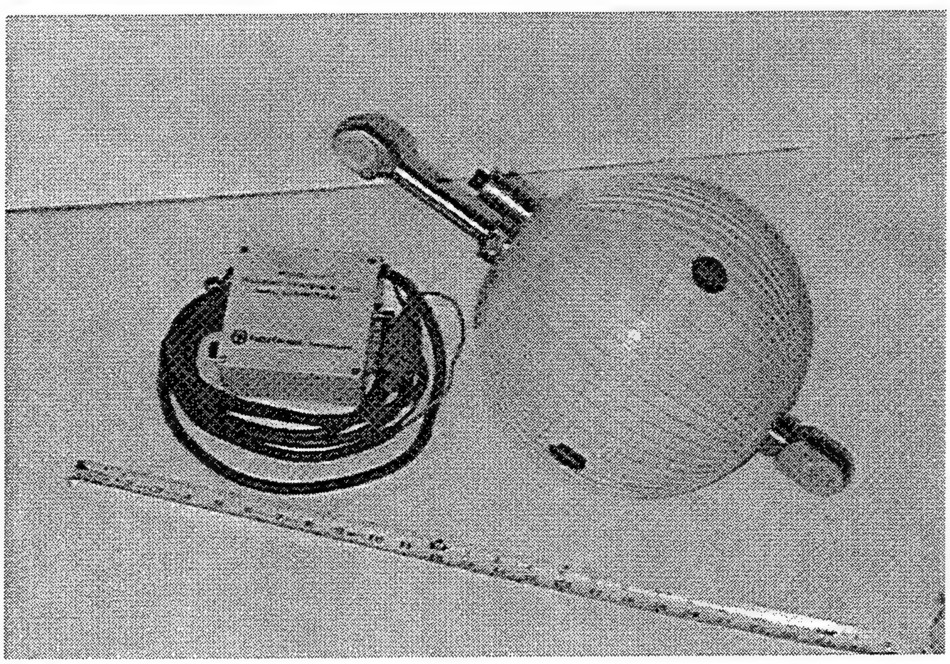


Figure A7. InterOcean S4 electromagnetic current meter

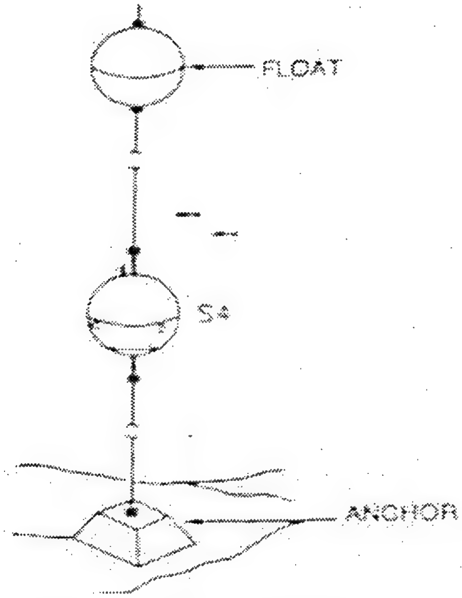


Figure A8. Electromagnetic current meter deployment technique.

Suspended Sediment Sampling

Pumped Water Samples

In combination with the over-the-side velocity measuring equipment, water samples for analysis of suspended sediment concentrations and total suspended solids are obtained by pumping the sample from the desired depth to the surface collection point. The pumping system consists of a 1/4 inch ID plastic tubing attached to the current meter signal cables for support. The opening of the sampling tubing is attached to the solid suspension bar at the same elevation as the current meter and is pointed into the flow. A 12 V dc pump is used to pump the water through the tubing to the deck of the boat where each sample is then collected in individual 8 oz plastic bottles. The pump and tubing are flushed for approximately 1 min at each depth before

collecting the sample.

Automatic Water Samplers

The ISCO Model 2700 automatic water sampler, shown in Figure A9, and the American Sigma Models 700 and 2000, are employed to provide unattended sampling. A typical field installation of these water samplers is shown in Figure A10. Samples are collected in 1 liter plastic bottles located inside the sampler. The samplers are fully programmable, operating from a 12 V dc power source, for obtaining any volume of sample desired up to the maximum size of the bottle, for obtaining composite samples, for setting different intervals between samples, and for setting times to begin the sampling routine. During servicing, the sample bottles are replaced with empty bottles to begin a new sampling period.

Figure A9. ISCO Model 2700 automatic water sampler

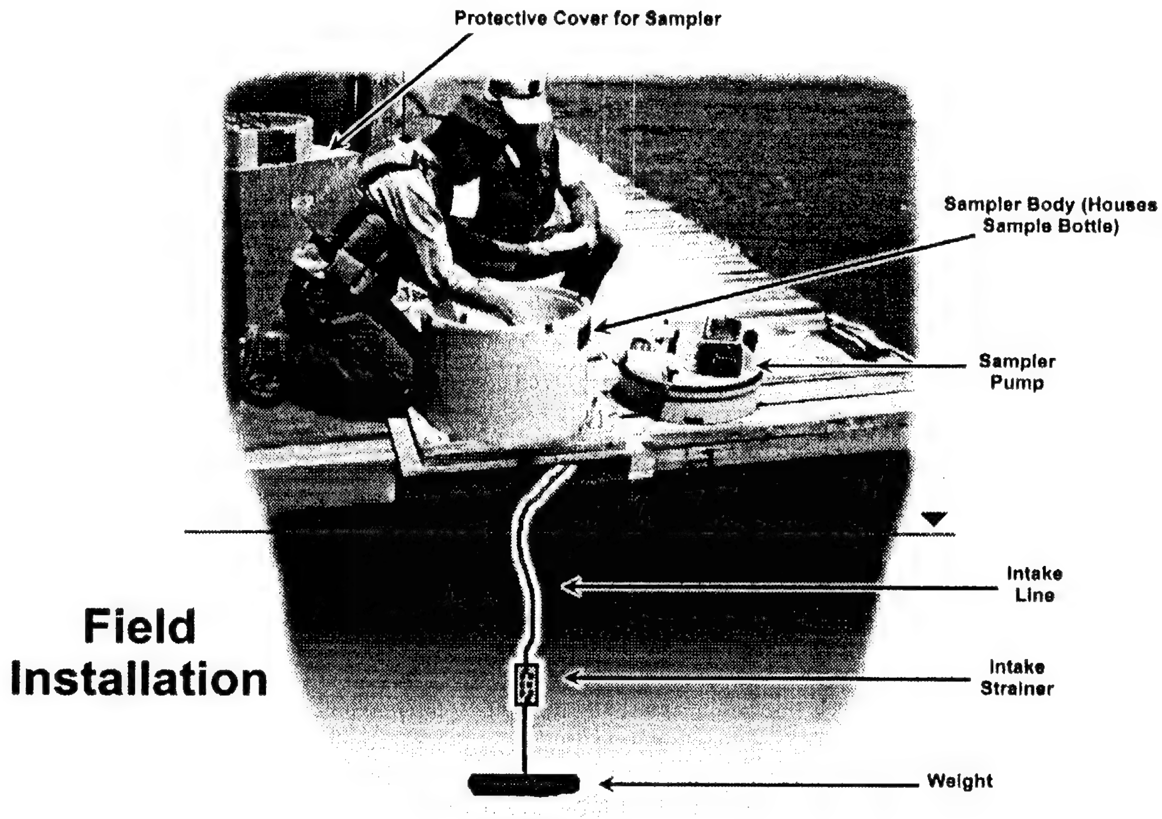


Figure 10. Typical field installation of automatic water samplers.

Optical Backscatterance (OBS) Sensors

The OBS sensor, a product of D& A Instruments and Engineering, is a type of nephelometer for measuring turbidity and solids concentrations by detecting scattered infrared light from suspended matter. It consists of a high-intensity infrared emitting diode (IRED), a series of silicon photodiodes as detector and linear solid state temperature transducer. The IRED emits a beam at angles 50° in the axial plane and 30° in the radial plane to detect suspended particles by sensing the radiation they scatter, as shown in Figure A11. Scattering by particles is a strong function of the angle between the path of radiation from the sensor through the water and the signal return to the detector. OBS sensors detect only radiation scattered at angles greater than 140°. As with other optical turbidity sensor, the response of the OBS sensor depends on the size distribution, composition, and shape of particles suspended in the medium being monitored. For this reason, sensors must be calibrated with suspended solids from the waters being monitored. The OBS sensor can be interfaced with "smart" data loggers that are capable of powering the sensor during sampling intervals.

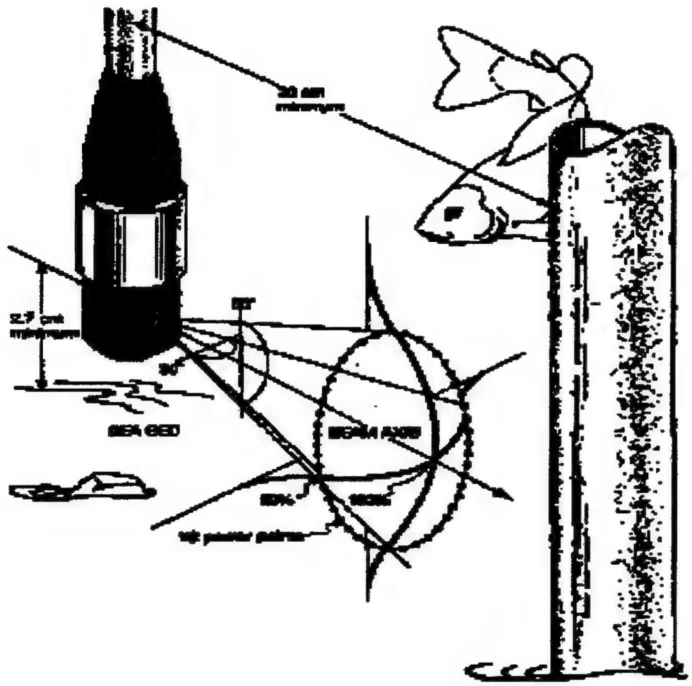


Figure A11. OBS sensor beam pattern

Salinity Measurements

Hydrolab DataSonde 3 Water Quality Data Logger

The Hydrolab Datasonde 3 Water Quality Data Logger, shown in Figure A12, provides conductivity and temperature with a computed salinity concentrations measurement corrected to a known calibration standard at 25° C. The recorder housing is a high-density PVC case with a specific conductance cell and temperature sensor. The specific conductance probe is a 6-electrode cell having a measurement range of 0.0 to 100 mS/cm with and accuracy of ± 1 mS/cm. The salinity concentrations range is from 0.0 to 40 ppt with an accuracy of ± .2 ppt (calculated from the conductivity). The temperature probe is a thermistor type sensor with a

measurement range of -5° to 50° C with and accuracy of ± 0.15° C. The data sampling intervals range from 1 - 59 sec, 1 - 59 min, or 1- 23 hr. Data is stored on non-volatile EPROM chips. Internal or external batteries provide the power requirements for sensor operation and data storage. Data is offloaded from the instrument via a industry standard RS-232 port to a PC or laptop computer using standard communiction software.

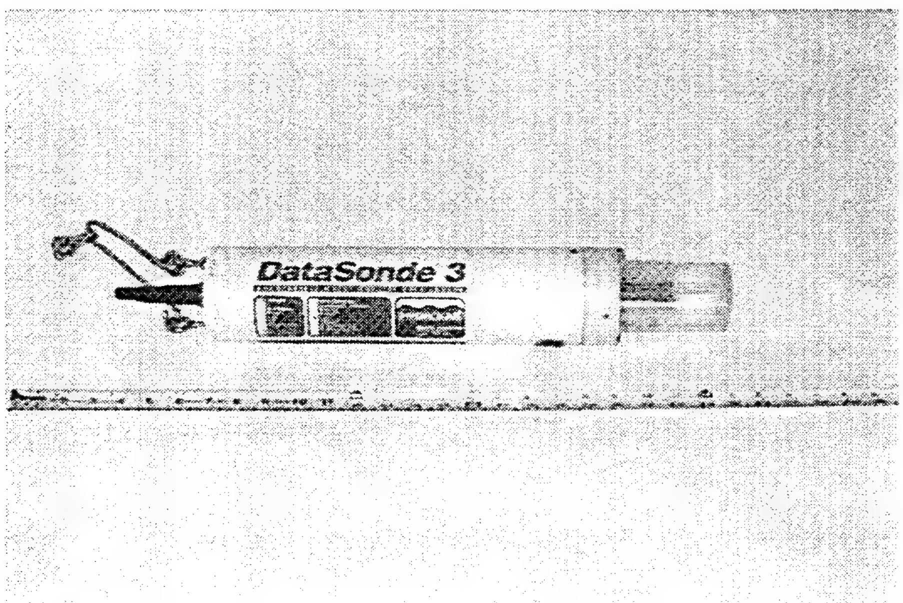


Figure A12. Hydorlab Datasonde 3 Water Quality Data Logger

Wave Height Measurements

Electronic Wave Height Recorders

The Micortide water level recorders, shown in Figure A13, contain a strain gage type pressure transducer in a subsurface case which records the absolute pressure of the column of

water above the case. The pressure transducer is not vented to the atmosphere, therefore an extra unit is positioned in the study area to record atmospheric pressure changes. Water pressure is measured for the desired sample interval and an average value is computed and stored on the internal RAM data logger. The stated accuracy is ± 0.02 ft. The sampling time interval can be set from 0.25 sec to 24 hours. The Microtide also measures temperature by means of a YSI thermilinear thermistor built into the water level recorder. The thermistor has a range of -5° C to +45° C, with a stated accuracy of ± 0.1° C. The data from each recorder is stored on an accessible RAM located in the waterproof subsurface unit which also contains the DC power supply.

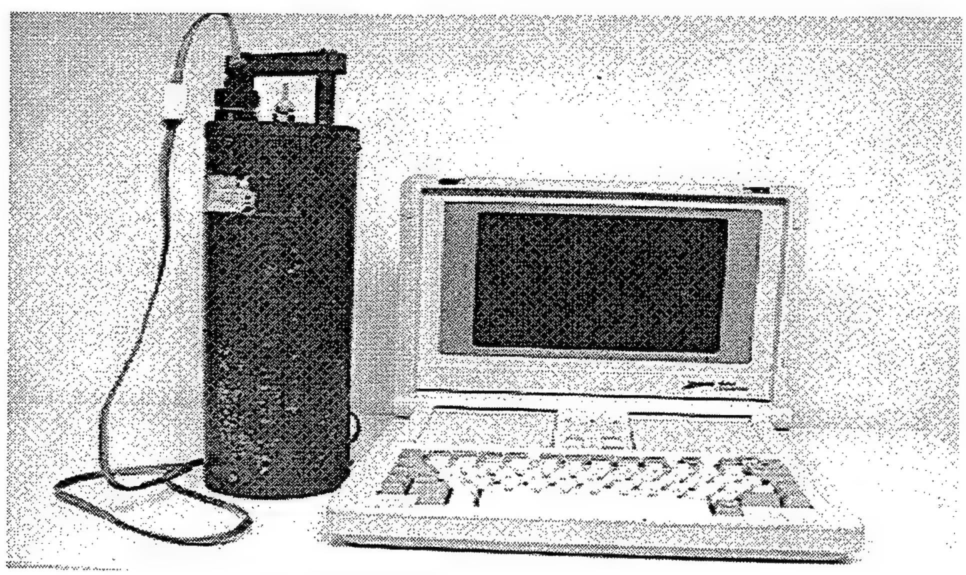


Figure A13. Microtide electronic wave height recorder

Water Level Measurements

Electronic Water level recorders

Water level elevation measurements can also be recorded using solid state electronic recorders, such as Microtide and YSI/ENDECO water level recorders. Water level elevations, temperature, conductivity, salinity, and dissolved oxygen (DO) concentrations measurements, are recorded using Yellow Springs Instruments/Environmental Devices Corporation (YSI/ENDECO) model YSI-6000 water level recorder, and YSI/ENDECO models 1152 SSM and 1029 (solid state measurement) water level recorders (excluding the DO concentrations). The ENDECO model 1152 SSM, shown in figure A14, and 1029 recorders, contain a strain gage type pressure transducer located in a subsurface case which records the absolute pressure of the column of water above the case. The pressure transducer is vented to the atmosphere by a small tube in the signal cable to compensate for atmospheric pressure. The pressure is measured for 49 seconds of each minute of the recording interval with a frequency of 5-55 KHz to filter out surface waves, therefore eliminating the need for a stilling well. The accuracy is ± 0.05 ft. The sampling time interval can be set from 1 minute to 1 hour. The 1152 and 1029 also measure temperatures by means of a thermilinear thermistor built into the recorders. The thermistor has a range of -5° C to +45° C, with an accuracy of ± 0.2 C. The 1152 measures conductivity by an inductively coupled probe installed on the meter. These measurements and the measurements of temperature are used to calculate salinity concentrations in units of parts per thousand. The salinity concentrations are computed with an accuracy of ± 0.2 ppt.

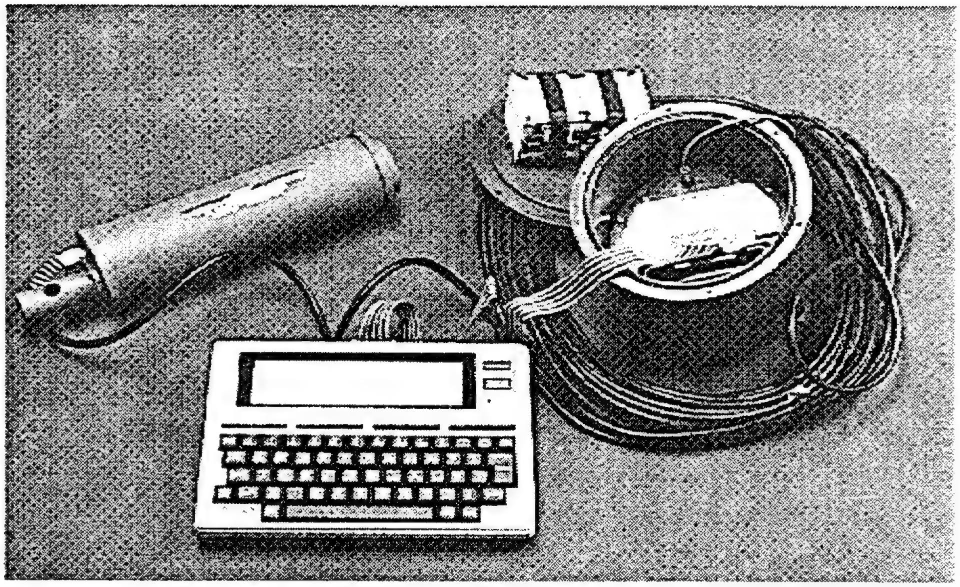


Figure A14. ENDECO model 1152 SSM water level recorder

The YSI/ENDECO model 6000 recorder also uses a strain gage type pressure transducer located in a subsurface case and records the absolute pressure of the water column above the case. The 6000 model is not vented to compensate for atmospheric pressure therefore after the sensor is initially calibrated, any changes in barometric pressure will appear as changes in depth. This is particularly significant in shallow water. For example, a change of 1 mm of Hg in barometric pressure will change the apparent depth by approximately 0.045 ft. The range of 0 - 30 ft of water has an accuracy of ± 0.06 ft and a resolution of 0.001 ft. The 6000 utilizes a thermistor of sintered metallic oxide which changes predictably in resistance with temperature variations. The thermistor has a range of -5° C to +45° C, with an accuracy of ± 0.15° C and a resolution of 0.01° C. The 6000 measures conductivity using a four nickel electrode cell in the range of 0-

100 mS/cm with an accuracy of ± 0.5 percent and a four digit resolution. Salinity is calculated based on the conductivity and temperature measurements in the range of 0-70 ppt with an accuracy of 1.0 percent or ± 0.1 ppt and a resolution of 0.01 ppt. The 6000 uses a dissolved oxygen (DO)sensor that employs a patented "Rapid-Pulse" measuring technique. Its range is 0-20 mg/l with an accuracy of ± 0.2 mg/l and 0-200 percent saturation with an accuracy of ± 2 percent. Dissolved oxygen is not needed for the study, but the conductivity sensor on these units is mounted in the dissolved oxygen sensor and cannot be separated. All parameters are recorded at 15-minute intervals and can be logged for up to 50 days.

The sampling time interval for conductivity and temperature cannot be set independently from the water level measurements. The data from each recorder is stored on a removable EPROM solid state memory cartridge located in a waterproof surface unit which also contains the DC power supply.

Bottom Sediment Sampling

Push Core Sampler

Bottom sediment are obtained using a push core type sampler. The sampler consists of a 1-1/2-in-dia PVC pipe, 18 inches in length. Attached to this is a smaller section of pipe with a valve attached at the upper end. The purpose of the valve is to create a reduced pressure holding the sample in the larger diameter pipe. The samples are then brought to the surface and classified by visual inspection or transported back to WES for more detailed analysis. The push

core sampler is displayed in Figure A16.

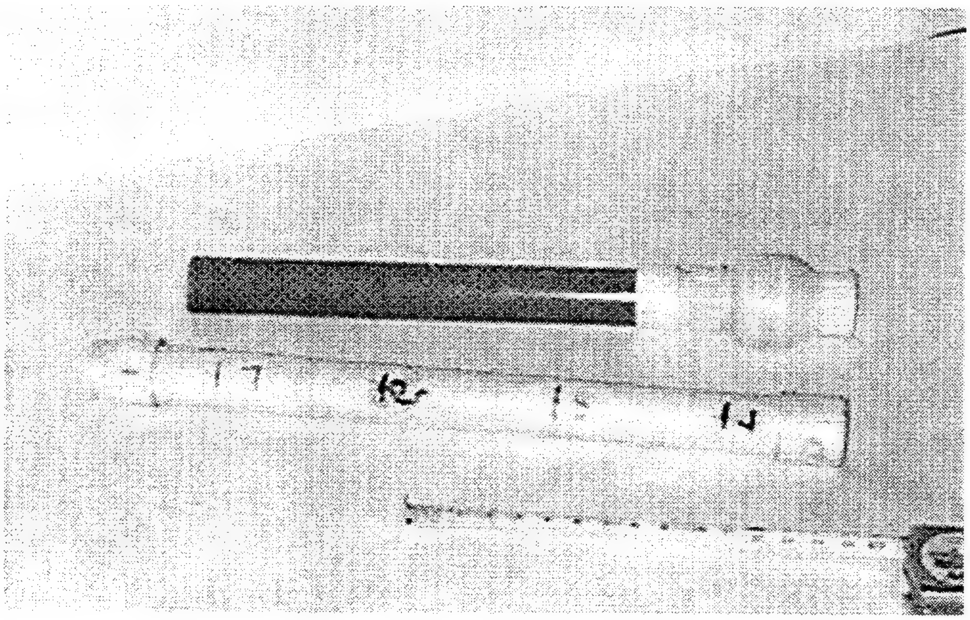


Figure A16. Push Core Sampler

Petite Ponar Sampler

The petite Ponar sampler is basically a clam-shell type sampler. The sampler is cocked on the surface before lowering to the bottom. When the sampler makes contact with the bottom the trigger pin releases allowing the sampler to close. As the sampler is raised to the surface it closes around the captured sediment until it is opened at the surface. Samples are removed, inspected and packaged in plastic bags or jars for further analysis once returned to WES. The Petite Ponar is displayed in Figure A17.

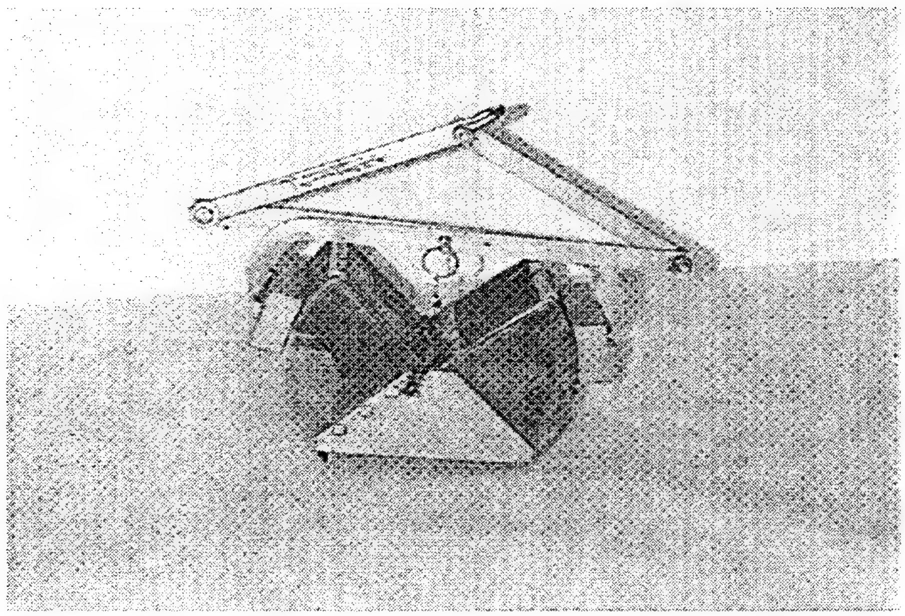


Figure A17. Petite Ponar Sampler

Box Core Sampler

The Box Core sampler is very similiar to the Petit Ponar in its triggering mechanism and sampling technique. The main difference in the two samplers is where the sample is trapped. The Box Core has clam-shell jaws that scope the sediment into a clear plastic square tube. When the sampler is opened at the surface the sample is visible from a top door on the sampler. From this top door the trapped sample can be sub-sampled for more detailed analysis. Figure A18 is a picture of the Box Core Sampler.

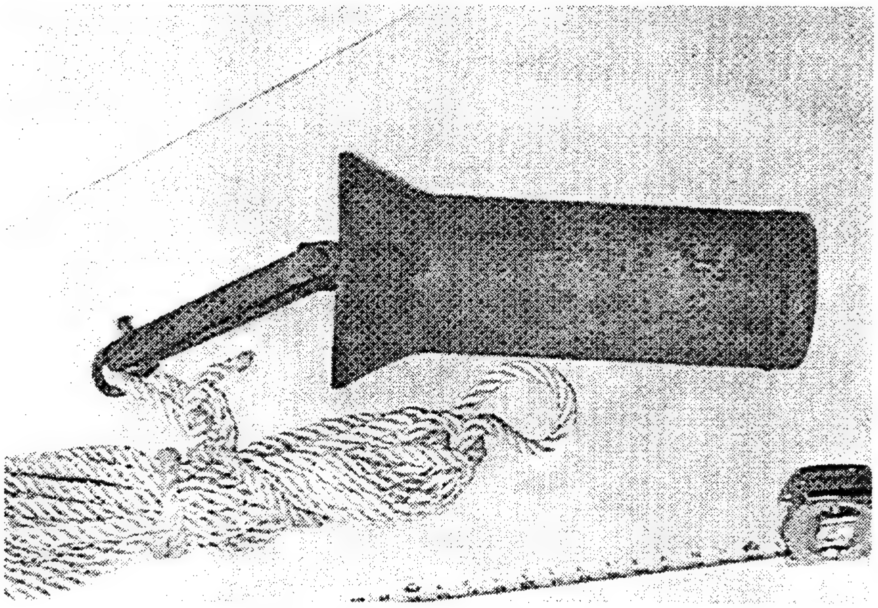


Figure A18. Box Core Sampler

Tethered Drag Sampler

The Tethered Drag Sampler is basically a 3 inch diameter pipe cut on a 45 degree angle with a shackle mounted on one side. The sampler is thrown over the side and drug along the bottom. The sample accumulates inside the pipe. Samples are removed, inspected and packaged in plastic bags or jars for further analysis once returned to WES. The Tethered Drag Sampler is displayed in Figure A19.

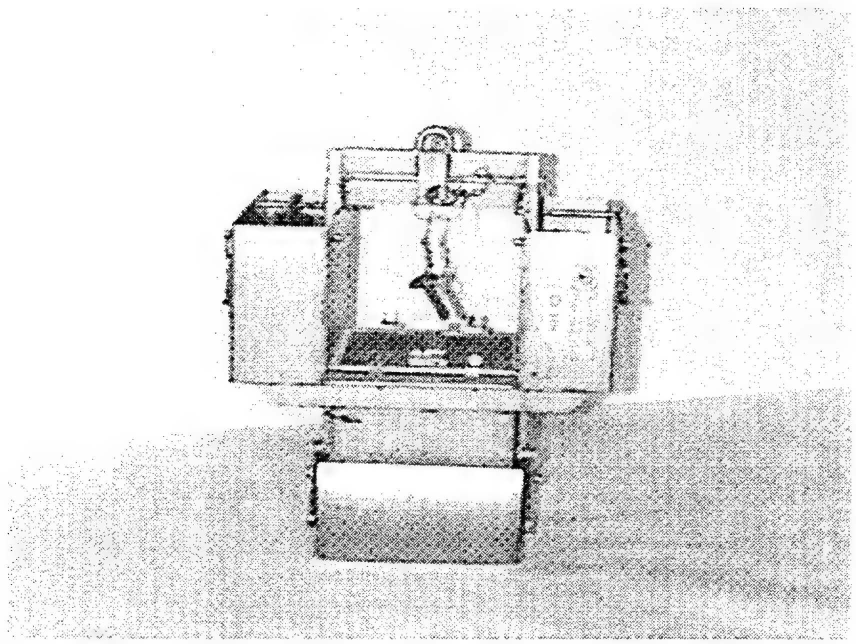


Figure 19. Tethered Drag Sampler

Meteorological Measurements

Digital Data Acquisition of Meteorological Data

Continuous wind speed and direction measurements are recorded using a Campbell Scientific Model W2000 Data Acquisition system (see Figure A20). The data collection platform is typically located at some central location in the study area and mounted approximately 5 meters above the water. The data acquisition system is a battery-powered microcomputer with a real-time clock, a serial data interface, and programmable analog to digital converter. The battery is constantly charged using a solar panel charging system located near the system. Various programming options are available for setting the sampling interval of

the system for the input signals from the wind speed and direction sensors. The system can be programmed to sample the input signals each second over a set period of time to determine the mean wind speed, mean direction, maximum wind gust speed and maximum wind gust direction. The data is processed internally and stored in formats specified in a user-entered output table. The accuracy of the analog input of the wind speed and direction sensors are ± 1.0 mph and ± 3.0 degrees, respectively. The Barometric Pressure sensor, model CS105 has an accuracy of ± .5 millibars for a range from 600 to 1060 millibars. The Tipping Bucket Rain Gage has an resolution of 0.01 inch for each tip. The calibrated accuracy is ± 1 tip or 1 percent at 2 inches per hour or less.

The relative humidity sensor has a accuracy of ± 2 percent RH within the range of (0-90 percent) and ± 3 percent RH within the range of (90-100 percent).

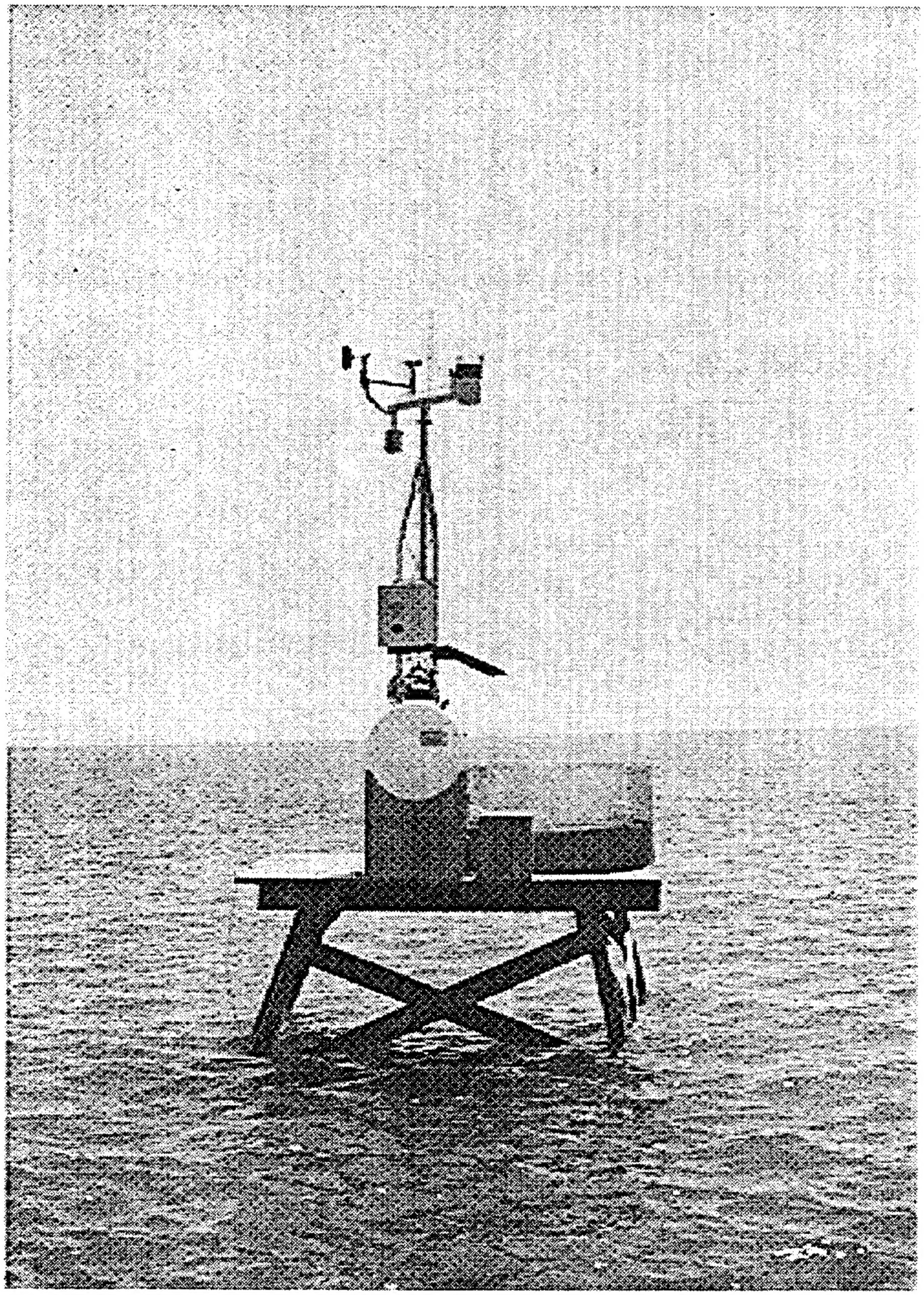


Figure A20 Weather Station W2000

Laboratory Equipment and Sample Analysis

Laboratory Analysis for Salainity concentrations

An AGE Instruments Incorporated Model 2100 MINISAL salinometer (Figure A21) with automatic temperature compensation is used for the determination of suspended sediment concentrations in the individual samples. The salinometer is a fully automated system, calibrated with standard seawater, and the stated manufactures accuracy is ± 0.003 ppt on samples ranging from 2 to 42 ppt.

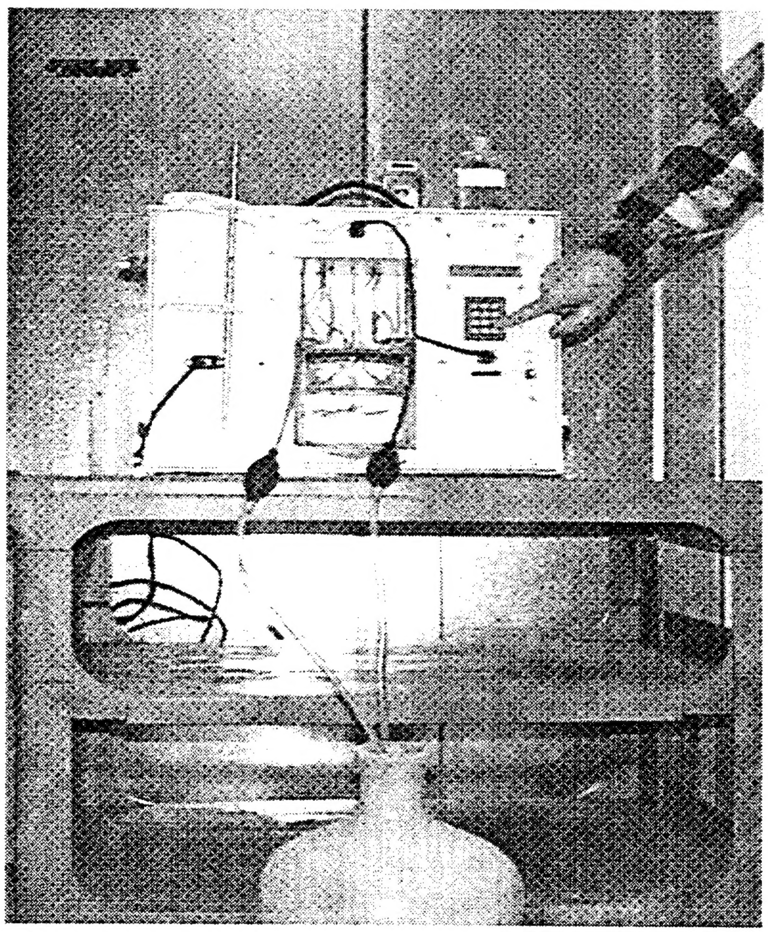


Figure A21. AGE MINISAL salinometer

Laboratory Analysis for Total Suspended Materials

Total suspended materials (TSM) are determined by filtration of samples. Nuclepore (Registered Trademark) polycarbonate filters with 0.40 micron pore size are used. They are desiccated and preweighed, then a vacuum system (8-lb vacuum maximum) is used to draw the sample through the filter. After the filters and holders are washed with distilled water, the filters are dried at 105 deg C for 1 hr and reweighed. The TSM are calculated based on the weight of the filter and the volume of the filtered sample.

Density analysis

A density analysis is done using wide-mouth, 25-cm constant-volume pycnometers. They are calibrated for tare weight and volume. A pycnometer is partially filled with sediment and weighed, then topped off with distilled water. Care is taken to remove any bubbles before the pycnometer is reweighed. The bulk density (BSG) of the sediment is then calculated by the equation:

$$BSG = \frac{(p)(sedwt - tarewt)}{(p)(volpyc) + (sedwt) - (sed + waterwt)}$$

where:

p =density of water at temperature of analysis

sedwt = weight of pycnometer with sediment

tarewt = tare weight of pycnometer

volpyc = volume of pycnometer

sed + waterwt = weight of pycnometer with sediment and water

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13. ABSTRACT ***(Maximum 200 words)***

This report documents a hydrodynamic field investigation conducted to provide data for the development of a three-dimensional hydrodynamic model of the San Juan Bay and Estuary System in Puerto Rico. Representative results of a field investigation of the San Juan Bay Estuary System conducted from 22 June to 19 August 1995 are presented. They include short-term measurements of current speed and direction, salinity profiles, water samples, and water-level fluctuations. Long-term measurements include water-level monitoring, salinity measurements, and fixed-depth current speed, direction, and salinity. Field investigation equipment and methods used to collect the data are described, representative results of the data reduction methods are presented, and results of the investigation are summarized.

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